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FORWARD

Managers of renewable natural resources, including forests, are facing increasingly complex problems, mainly brought about by the goals which man sets for himself. Demands are not satisfied by letting nature take its course. Managers must produce more of better quality and in a shorter period of time. To meet the demands more knowledge is needed by forest managers about the environment and how to improve the productivity of Ontario's forests. The gathering of such knowledge and understanding calls for careful objective experimentation and observation, and often requires a sustained systematic approach.

To this end, Mr. W.T. Foster, the Deputy Minister of Natural Resources, announced the strengthening of provincial forest research, formerly undertaken by the Ontario Forest Research Centre, by the formation of the Ontario Tree Improvement and Forest Biomass Institute, effective October 1, 1981. The much needed infusion of money from the Board of Industrial Leadership and Development program has increased the impetus for research in genetics, biotechnology and site ecology. Along with this renewed drive must be a new effort in technology transfer to ensure that forest managers are aware of research results.

Additional land for developing planting stock has been obtained at our Maple Research Station, and new equipment storage buildings have been constructed at both Midhurst and Maple. Furthermore, our laboratories and greenhouses will be renovated and expanded and a new office complex is under development with the Ministry of Government Services.

In addition to the many existing forest management problems, the Ministry has increased the number of forest management agreements with the forest industry which will heighten the demand to provide research answers critical to the future success of these agreements.

We at the Institute are proud of our research achievements and look foward to increasing even further our accomplishments in forest research to provide the forest managers with new and more efficient tools for forest management.

D.P. Drysdale
General Manager
Ontario Tree Improvement and
Forest Biomass Institute

HIGHLIGHTS OF THE YEAR

- Initiation of tissue culture work
- Delimitation of some jack pine populations through isoenzyme analyses
- Expansion of international cooperative work by visiting scientists
- Production of tables to assess the yield potential of red pine stands undergoing different thinning schedules
- Development of the 2nd Approximation Forest Ecosystem Classification

INTRODUCTION

This annual summary of selected research activities of the Institute is arranged somewhat differently from previous years to conform to new policies and to reflect internal changes in organization.

The first section describes some of the work and findings in studies on: breeding, productivity and the requirements of poplar, willow and alder; tree improvement and genetics -- including tissue culture -- of spruces, pines, larch and some hardwoods; physiological and morphological studies on the production and performance after outplanting of coniferous planting stock; and stand management and productivity investigations in natural and planted conifer and hardwood stands.

Subsequent sections outline support services, the dissemination of research results through meetings and publications, budget, staffing and organization.

BREEDING, PRODUCTIVITY AND REQUIREMENTS OF FAST GROWING HARDWOODS

Poplar Breeding

The purpose is to develop fast growing, pest resistant varieties of poplar of desired biomass quality. This year, population studies, gene pool collections and selections in eastern cottonwood (Populus deltoides), trembling aspen (P. tremuloides) and balsam poplar (P. balsamifera) were started. Hybridization continued, as well as progeny testing and clonal selection. Karyo-type studies in hybrids were initiated. Studies into resistance of poplar clones to disease pests continued.

The results to date have provided clonal selections of hybrid poplar for the management program.

Studies in Native Poplar Species

For eastern cottonwood, the identification of the species-range in Ontario and the selection of representative female-tree specimens have almost concluded. The analysis and propagation of this material is in progress. To date, 37 selections have been made, with 12 propagated by cuttings and 27 propagated by half-sibs.

Collections of trembling aspen and balsam poplar were initiated, as well as genetic variation studies, by Dr J. Hyun, postdoctoral fellow (trembling aspen) and K. Falusi, PhD student (balsam poplar). The collections are made according to site districts; seeds and vegetative propagules are collected and propagated. The genetic variation study involves isoenzyme analysis and the effects of different growth regimes.

Hybridization

The following crosses were attempted: P. alba x grandidentata (2), P. alba x nigra (2), P. alba x tacamahaca Mill (2), P. (grandidentata x canescens) x alba (2), P. (grandidentata x canescens) x deltoides (2), P. (grandidentata x canescens) x tremula (2), P. (grandidentata x canescens) x tacamahaca (2), P. (grandidentata x canescens) x nigra (2), P. deltoides x deltoides (4), P. deltoides x nigra (1), P. deltoides x Maximowiczii (2), P. deltoides x tacamahaca (5), P. nigra x deltoides (1), P. nigra x Maximowiczii (2), P. nigra x tacamahaca (2), P. tacamahaca x deltoides (4), P. tacamahaca x Maximowiczii (4) and P. tacamahaca x nigra (2). Most of the crosses with P. deltoides as female parent produced good seed, while the results with the rest of the crosses were very variable, with many failures.

Progeny Trials of Interspecific Hybrids

The full-sibs produced by artificial pollination are established in the field, in replicated trials. These trials provide information for studies on genetics and combining ability, and are also important sources of new clones. To date, 9 progeny trials of interspecific hybrids have been established in southern Ontario, and 3 in northern Ontario.

New Clonal Selections

In 1980-81, the first clonal selections were made from 4- and 5-year-old progeny trials of interspecific hybrids. The outstanding ortets selected were of P. deltoides x Maximowiczii and P. deltoides x nigra parentage (2 clones from each).

Cytogenetic Studies

Chromosomes in mitotic and meiotic divisions were studied in Populus intersectional hybrids and in trees treated earlier with polyploidy-inducing agents. In some of these the polyploidy status was established. Several hybrids showed a significant level of meiotic aberrations, which could lead to sterility.

(Zsuffa)

Breeding for Disease Resistance

Disease surveys (under contract with Dr M. Hubbes, University of Toronto), provide data for clonal selection and breeding for disease resistance and to the understanding of resistance mechanisms in poplar. Disease surveys concentrated on leaf-rust (Melampsora spp.), Marssonina leaf spots, Dotchichiza canker, Septoria canker and bacterial cankers.

(Zsuffa-Hubbes)

Breeding of Willows and Alders for Biomass

Willows (Salix L. spp.) and alders (Alnus Mill spp.) are pioneering, fast growing species. They are easy to hybridize and clone (by rooting cuttings) and they regenerate after harvesting by resprouting. In addition, alders are nitrogen-fixing. In 1981, willow selection and breeding programs were intensified, and alder selection and breeding was started. An alder species collection program was started within the framework of IEA-Forestry Energy cooperation.

(Zsuffa)

Studies in Natural Willows

In willows, the selection and collection of specimens of importance for biomass production and their taxonomic identification was started in northern Ontario by contract with Dr J. Eckenwalder, Department of Botany, University of Toronto. The sampling is according to Hills' site districts and includes plant material for vegetative propagation and documentation of the collection. An exploratory study of native willows in southern Ontario was started as well. Collections of promising willow clones were obtained from Sweden and England.

(Zsuffa-Eckenwalder)

Cytotaxonomy of Willows

An exploratory study in cytotaxonomy of willows has been accomplished. The 2n chromosome numbers were checked in root tips and expanding leaves. Species and interspecific hybrid specimens were included in the study. The results contribute to the knowledge of taxonomical and genetical relationships in Salix species and hybrids and help to formulate an effective breeding program.

(Raj)

Alder Collection

In alders, a worldwide collection of specimens (half-sib seed collection) was started in cooperation with the International Energy Agency's Forestry Energy Program. To date, the following collections have been obtained: Alnus cordata Desf. (18 collections), A. cremastogyne Burk (1), A. glutinosa (1) Gaertn. (13), A. hirsuta (Spach) Rupr. (1), A. incana (L.) Moenck spp. tenuifolia Nutt (5), A. japonica (Thumb) Steud (1), A. jorullensis H.B.K. (1), A. nepalensis D. Don (1), A. rubra Bong. (45), A. sinuata (Reg) Rydb. (4), A. trabeculos Hand. (1), A. viridis DC spp. fruticosa Rupr. (10).

(Zsuffa)

Frost Hardiness Testing of Poplar Clones

The development of testing procedures to determine genetic differences in frost hardiness in poplar clones was initiated in 1981. The immediate objective is to develop rapid methods of assessing frost hardiness and its seasonal pattern, which will help in screening progenies and clones in breeding trials. Electrical impedance and conductivity are used together with freezing treatment and viability test, such as subsequent growth after freezing. Special attention is being paid to the development of systems for data synthesis and analyses.

(Pelkonen and Glerum)

Establishment and Growth

Minicuttings

Horizontally planted poplar and willow cuttings of several lengths, planted and recoppiced in 1980 were re-evaluated in 1981. Resprouted DN113 from 25-cm-long horizontal cuttings was 20% shorter than from vertical cuttings while I-45/51 was

about 10% taller. However, for cuttings of 12 cm length, current sprouts of DN113 and I-45/51 were 15 and 30% shorter than their respective 25 cm vertical "controls".

Additional horizontal planting studies confirmed the positive relationship of both survival and growth to cutting length. Significant clonal variation existed in the ability of poplars to root from small (6 cm long) cuttings. Willows rooted well from short cuttings, however, and performed well when "sown" in a "broadcasting" fashion. Future studies will investigate the use of hormones to promote more rapid and abundant rooting.

Current growth of residual sucker stems in an aspen plantation at Leitrim, harvested at age 6 and cleaned at age 6+2, indicated that diameter growth increased due to thinning at the expense of height growth. Post thinning mortality (0-22%) and shoot growth (0.54-0.94 $m.a^{-1}$) varied among the 6 populations under study.

(Anderson)

Site Preparation and Stock Type for Dual-Crop Forest Systems

Dual-crop forest systems are being developed where short-rotation, fast growing species such as hybrid poplar and European alder, etc. would maximize site utilization and provide intermediate yields of quality fibre followed in rapid succession by second story timber crops. The sites used encompass a range of physiographic conditions in central and southwestern Ontario.

Continuous mechanical cultivation can be equally effective as a number of chemomechanical treatments in stand establishment. Chemomechanical tilling showed particular advantages if carried out intensively prior to planting. This approach generally limited the need for prolonged, costly and often injurious post-planting interventions particularly in closely spaced plantations. However, chemomechanical site treatments required considerable technological expertise in regard to ground cover types, phenology, selectivity of herbicides, rates of application, site characteristics, etc.

Planting stock types and depth of planting have considerable bearing on the initial survival and growth of hardwoods on upland sites. For instance, unrooted sectional poplar cuttings, regardless of length (25-50 cm), consistently suffered higher mortality than the rooted stock. But deeply planted, long (1 m+) unrooted terminal whips (sets) generally resulted in a better survival and terminal dominance. Utilization of whips containing terminal portions of poplar stems is recommended for use in reforestation projects on marginal sites. In the long run, the surviving trees on adequately prepared areas generally tend to equalize in size. However, planting in sod with subsequent repeated herbicide spraying proved least successful, suffering from progressive retardation and mortality over a prolonged time period.

Indications of intrinsic compatibility and allelopathic relationships among species are progressively becoming evident. In mixedwood plantations, optimum development was observed for such associations as European alder-poplar, European alder-white ash, black locust-basswood, hybrid aspen-red oak. Allelopathic influences of various associations require further basic investigations; however, there is sufficient evidence that a number of species combinations are mutually beneficial and would provide considerable advantages in operational planting.

Establishment on Marginal Sites

Some 14 sources of poplar were set out 7 years ago as decapitated rooted and sectional unrooted cuttings on an area which had been sod-farmed for 13 years. The area was not only depleted of topsoil but also showed serious deficiencies of phosphorus and low levels of potassium.

Four complete replications of all sources were established in two blocks of which one was lightly cultivated while the other was first treated with liquid waste effluent and then cultivated in similar manner. The effluent, which consisted of urban-type wastes, was delivered

from the adjoining trailer park and discharged over the area from May to October for 7 consecutive years. The average quantity of effluent applied annually amounted to about 40 mm of surface irrigation (or about 400 m^3 of effluent per hectare).

The ability of the individual clones to survive on the top-soil-depleted, untreated area varied widely, reflecting their inherent potential for site tolerance. The survival ranged from 17% for I-45/51 to complete mortality of I-455. In some instances good survival was also combined with above-average general performance; however, such combinations were not frequent.

Effluent application reduced mortality for all clones. This was particularly pronounced in clones which generally sustained highest mortality in the control group. Volumes per hectare were calculated and ranked for all 14 clones. In this trial, production of 10 m^3/ha was arbitrarily established as the lower limit for clones acceptable for reforestation of the depleted, effluent treated sites.

A Relative Amelioration Index (RAI) was used by calculating the ratio of improved:depleted yields for individual cultivars, to compare their clonal amelioration potential (Table 1). Those RAI values diverging from unity indicated an increasing potential for clonal improvement with effluent treatment. However, clones of above-average general performance and with RAI values approaching unity have shown a particularly high efficiency and ecological stability under a variety of site conditions.

Determination of the environmental stability of the individual clones both as to their inherent characteristic and in relation to treatment was accomplished by comparisons of the Coefficients of Variation (CV) calculated for the diameters and heights. Effluent application consistently resulted in both increased growth and a more uniform development of the trees.

(Jaciw)

Dry Matter Productivity

The purpose of this work is to compare the effects of growing conditions on the dry-matter production of various hybrid poplar and willow clones, especially for minirotations.

Clonal Trials

Twenty-four hybrid poplar clones planted in 1977 and grown in 2-year rotation at 0.3 x 0.9 m spacing were harvested at Kemptville. Significant clonalvariation was noted in stool survival, stem diameter and replication effect. Significant variation in leafless oven-dry biomass productivity was detected when statistical adjustment was made for survival and replication. The highest productivity on a single plot basis was noted for DN133 (2.0 od $kg.m^{-2}$, or 1.0 od $kg.m^{-2}.a^{-1}$), which also showed the highest survival (80%). However, average survival was less than 70% for all clones.

Current sprouts of 23 hybrid willow clones planted at 0.3 x 3.0 m were harvested from stool beds at Midhurst. Highest oven-dry productivity was calculated for SP-3 and SV-1 (0.6 od $kg.m^{-2}$). Prediction equations for estimating oven-dry mass of individual stems from physical measurements varied somewhat from parameters calculated in previous years. Reasons for this source of variability will be investigated through additional sampling and computer analysis.

Seasonal sprouts of 133 hybrid poplar clones growing at 0.3 x 2.0 m in the Institute arboretum were sampled in connection with an energy survey project. Oven-dry biomass productivity of these clones averaged 0.73 + 0.34 od $kg.m^{-2}$ with 3 clones exhibiting productivities exceeding +2 standard deviations of the mean. Maximum productivity was 1.9 od $kg.m^{-2}$ for DN182.

Spacing Trials

A plantation of 7 hybrid poplars grown at spacings ranging from 20 x 40 cm to 80 x 40 cm in two-year

TABLE 1 Ranking and growth of selected poplar clones after 7 years response to treatment with effluent

Effluent treated					Control			
Rank	Clone	Survival %	Vol/ha m^3	RAI	Rank	Clone	Survival %	Vol/ha m^3
1	Baden 431	100	20.9	1.3	1	Baden 431	96	15.9
2	I-45/51	100	13.2	1.8	2	I-45/51	97	7.4
3	Blanc du Poitou	100	12.6	5.0	3	Allenstein	83	5.9
4	Allenstein	100	11.2	1.9	4	Robusta	62	3.0
5	Robusta	100	9.9	3.3	5	Blanc du Poitou	87	2.5
13	I-B-56	71	2.3	1.9	12	I-B-56	58	1.2

rotation was harvested at Midhurst. Biomass yield decreased with greater spacing for all but 1 clone (DN133). Maximum productivity on a single plot basis was 1.02 od $kg.m^{-2}$ (0.51 od $kg.m^{-2}.a^{-1}$). However, there was much variation due to replication effect, such that the highest average yield was 0.36 od $kg.m^{-2}$ (0.18 od $kg.m^{-2}.a^{-1}$) for I-45/51. This is attributable to the variable but generally poor site conditions under a non-fertilized growth regime, since survival was quite high (>85% in most clones). The performance of I-45/51 was quite consistent, reinforcing the observation that it has a broad site tolerance and thus its use as an "index" clone.

Current sprouts of hybrid willow planted in 1980 at 2 spacings (0 x 1.0 m and 0.15 x 0.15 m) were harvested and the stools were recoppiced. Subsequent sprouts averaged 6 to 20% taller, 15 to 30% larger in basal diameter, and had 120 to 230% more sprouts per stump in the wider spacing, depending on the clone. The narrow spacing will be harvested on a 1-year rotation and the wider on a 2-year rotation to compare biomass productivity rates.

Energy

Through funding from the Ontario Ministry of Energy, a two-year study was initiated to compare the energy production of current sprouts of 133 hybrid poplar clones. Gross heat of combustion, bark content, specific gravity, lignin and extractive content and growth rates are being jointly studied. Final results will allow selection, for further breeding work, of clones which maximize energy productivity at minimal nutrient drain from the site.

A cooperative study with the University of Toronto of the energy content of bark and wood from current sprouts of 15 hybrid willow clones indicated that clonal variation in energy content of bark varied from 4670 to 5001 $cal.g^{-1}$. These differences were associated with bark colour and preliminary data suggests a correlation between energy and extractive content. Considerable variation in lignin (26 to 35%) and specific gravity (0.284 to 0.396) was found among the clones. As a result of these findings, further cooperative work is underway to isolate and quantify the extractives and to define their energy characteristics.

A study of phenolic content of leaf tissue of 15 hybrid poplar clones revealed a significant clonal range (33.95 to 63.12 $mg.g^{-1}$). *Tacamahaca* and *Leuce* section hybrids had generally higher phenol contents than *Aigeiros* hybrids.

(Anderson)

Nutrition

Soil Nutrient Supply

Intensive management and cropping systems, such as of hybrid poplar plantations, make greater demands on soil nutrient reserves than do the more conventional extensive management systems of natural stands. We need to know more of the long-term capability of soils to provide nutrients, through weathering of mineral particles, to plantations.

Laboratory studies on the release of K, Ca and Mg were extended to the Ap, B and C horizons of Morrisburg and Bearbrook soil series which are typically used for hybrid poplar plantations. Previous nutrient release studies have been done for Grenville and Rubicon soil series. Initial results indicate significantly different nutrient supplying capacities of K, Ca, Mg, Fe and Mn by the 4 soil series studied, and significantly different long-term supplies of these nutrients in the Ap, B and C horizons in each soil series. Further analyses of data are required to provide knowledge of the long-term supply of cation in these soils in relation to the management of hybrid poplars.

(Lozano)

Extraction Methods

Numerous methods of extracting cations in soils are available but they are mostly developed and evaluated for short-term agricultural crops. Eight methods of extracting soil K, Ca and Mg were evaluated in relation to the concentration of such cations in the foliage, to the height and dbh of I-45/51 growing on the test soil. Regression analyses indicate that, in general, those extractants that measured not only the soluble and exchangeable but also the non-exchangeable fractions of these cations provide the best significant relationships, particularly K and Ca. Results also indicate that more of the total variance is explained if a separate extractant is used for each cation. Nonetheless, this procedure is too cumbersome for large numbers of soil samples. It would be more convenient and practical to use the same extractant to determine K, Ca and Mg. Either 0.5N HCl or 0.5N HNO_3 with 10-minute boiling procedures, which are both superior to all including the standard 1N NH_4OA_c, are recommended. Further studies will assess the applicability of these calibrated methods to a wide range of clones and soils.

(Lozano and Leech)

Relating Growth to Soil and Foliar Nutrients

Soil nutrients are widely recognized site factors influencing the growth of hybrid poplars, and knowing which nutrient element is limiting tree growth is vital information that a forest manager needs to know so that appropriate management practices can be effected to achieve a profitable plantation. A study was made of the relationships of height (m) or dbh (cm) at age 6 with that of selected nutrients, nutrient ratios and nutrient products (interactions) in the 15-cm surface mineral soils (kg/ha) and foliage (percent dry wt) of I-45/51 plantations. The objective was to assess the diagnostic and predictive value of soil and foliar analyses in determining the nutrient that is limiting to height and dbh. A stepwise multiple regression analysis provided height and diameter prediction equations from soil and foliar data of individual nutrients, nutrient ratios and nutrient interactions.

Soil analysis, particularly the strong-acid extractants, was a better predictor than foliar analysis, in this present study. Soil K (extracted by HNO_3), K/N and NK were related to both height and dbh in a highly significant level. Foliar Ca, CaMg, K and K/Mg were related significantly to height, with Ca and CaMg negatively and K and K/Mg positively related. Foliar Mg, CaMg and K/Mg were significantly related, but rather modestly, to dbh, with the former two negatively and the latter one positively. Further studies will assess the applicability of all of these relationships over a wide range of clones and soils.

Estimating Critical Levels of Nutrients

A study was made of the quadratic

relationship of height or diameter breast height (dbh) and that of selected nutrients in the 15-cm surface soil and foliage of 6-year-old test trees from two hybrid poplar I-45/51.

For the same plantation noted above, analyses were performed to establish critical levels of nutrients associated with maximum calculated heights and dbhs. The test trees had a maximum calculated height when soil N, P and K were 3511, 6.35 and 840 kg/ha, respectively and when foliar N, P, K, Ca and Mg were 2.88, 1.15, 0.18, 0.95 and 0.33 percent, respectively. Maximum calculated dbh occurred when soil N, P and K were 3575, 6.37 and 1000 kg/ha, respectively, and the foliar N, P and Mg were 2.73, 0.17 and 0.26 percent, respectively. Further studies will assess the applicability of these critical values of nutrients to a wide range of clones and soils.

(Lozano)

Nutrient Requirements of Clones

The nutrient requirements of each hybrid poplar clone must be known before fertilizers may be added advantageously in field situations. In greenhouse cultures, the concentration of each nutrient in a complete nutrient solution for poplar was, in turn, doubled, while concentrations of remaining nutrients were unaltered. Effects on growth and foliar nutrient concentration were recorded.

Leech and Kim (in OMNR Forest Research Information Paper No. 102) reported that growth may be inhibited even though the concentration of some foliar nutrients may double after the addition of fertilizer in excess. By calculating DRIS indices, the reason why the dry weight of overfertilized trees fell below that of trees supplied with only the complete nutrient solution may be understood (Table 2).

(Leech and Kim)

TREE IMPROVEMENT AND GENETICS

Spruce

Genetics

The overall objective of the spruce genetics program continues to be the production of genetically improved stock for regeneration. The research scientist formerly in charge of the project transferred to management in 1980, and J.V. Hood assumed his duties in January 1981. Following the typical developmental sequence of tree improvement programs, operations that were once research functions are now part of management procedures. While the overall program objective has not changed, the direction of research will be altered to emphasize increasing the efficiency of the various breeding procedures.

During 1981 most time on the program was allocated to reviewing and evaluating past work and to

TABLE 2 Effect of overfertilization on cuttings of clone I-45/51 (+ indicates excess, - indicates demand for nutrients)

Nutrient level		DRIS Indices[a] N	P	K	Ca	Mg
2N+P+K+Ca+Mg+S	1.6	+27.6	- 3.6	+ 5.0	-12.3	-16.7
N+2P+K+Ca+Mg+S	3.4	- 4.2	+ 3.5[b]	+12.7	+ 0.3	-12.4
N+P+2K+Ca+Mg+S	2.6	+19.5	+ 3.2	+37.1	- 4.2	-55.6
N+P+K+2Ca+Mg+S	3.2	+ 4.1	-15.1	+ 1.3	+60.0	-50.3
N+P+K+Ca+2Mg+S	3.1	-12.0	-20.2	+ 1.4	-22.3	+53.2
N+P+K+Ca+Mg+2S	4.0	+ 2.5	-26.6	+ 7.0	+ 6.8	+10.2
N+P+K+Ca+Mg+S	14.11	- 1.0	- 8.0	+ 5.0	+ 4.0	+ 0.0

[a] DRIS Diagnosis and Recommendation Integrated System of Beaufils.
[b] The 2P solution results in a more favourable level of foliar P than P alone in the solution but creates a demand for foliar N and Mg.

consulting with management to establish some research priorities.

A white spruce progeny test at Midhurst nursery was rated and analyzed for incidence of multiple-leadering (a recurring and annoying problem at the nursery). Although the differences among families was statistically significant, the proportion of the variation attributable to genetic differences was low. Additional data collected for correlation with later field performance. This test will be planted in the field, spring, 1982.

Although the role of interspecific hybridization as a source of immediate gains through hybrid vigour has decreased over the past several years, one cross that had not been ruled out was white spruce x sitka spruce (P. glauca x P. sitchensis). Two small trials of this cross were planted in 1974 in the Wingham and Bracebridge Districts. As of fall, 1981, native white was 19% taller at the more northern, Bracebridge site, while the hybrid was 10% taller at Wingham. These results do not support continued production of this hybrid as a high priority project.

A cooperative venture was undertaken with the Petawawa National Forestry Institute and the Pembroke District to establish a seed orchard of white spruce from Upper Ottawa Valley sources. This provenance, referred to as "Beechburg" in old tests, has indicated outstanding performance in a number of tests here and abroad. The project has three main objectives: to conserve this valuable genetic resource, to provide seed for the Algonquin region, and to establish a new and separate research orchard adjacent to the production orchard for studying orchard management techniques. (The PNFI contribution will be an integral part of their existing research mandate in white spruce genetics.)

(Hood)

Hybridization

Emphasis was placed on black spruce interspecific breeding in 1981. Controlled crosses were carried out in two breeding areas, Sault Ste. Marie and Algonquin Districts, using selected clones from Green River, New Brunswick, Geraldton and Thunder Bay. In the previous years, clones were used from Green River, New Brunswick, Cochrane, Geraldton and Thunder Bay.

There has been a considerable number of interspecific crosses initially reported as being successful in the literature which have subsequently proven to be failures, the seedlings resulting from contamination. Black spruce is known to cross sparingly with red spruce, readily with Serbian spruce and with considerable difficulty with Sitka spruce (see Forest Research 80). Only widely separated populations from areas where the ranges of the two species do not overlap appear amenable to low level artificial crossing. This is likely to be the case of black spruce crosses with Engelmann and also with white spruce. Black spruce rarely, if ever, crosses with white spruce (see Forest Research 77) from within their common range. Nevertheless, some of the foregoing crosses exhibit heterosis (hybrid vigour), notably those with Serbian spruce and also to some extent with Sitka spruce.

The most startling result of interspecific crossing attempts with black spruce is their consistent failures. In these crosses pollen parents were: Picea glauca, P. engelmannii, P. sitchensis, P. breweriana, P. chihuahuana, P. asperata, P. likiangensis and P. maximowiczii. In addition, pollen parents in previous years have also included P. schrenkiana, P. polita, P. purpurea, P. koyamai, P. abies and P. pungens. All were failures. P. sitchensis has been successful as the female parent (see Forest Research 80) and P. mexicana a failure. The increasing knowledge on the extent and particularly the level of interspecific compatibility in black spruce will provide a much better definition of the nature of our breeding base in this species and strategy for breaking incompatibilities.

In other hybridization, P. omorika, which was crossed successfully for the first time with P. asperata in 1980, was repeated in 1981. These species are genetically very distant and difficult to

cross. P. omorika x P. rubens hybrids were back-crossed successfully both to P. omorika and P. rubens. This hybrid was also crossed with P. mariana. Crossability was low.

Considerable effort is being directed toward clonal multiplication for difficult-to-make hybrids for progeny testing in different site regions. Among these being tested both as seedlings and clonal materialare: P. omorika x P. glauca, P. engelmannii, P. sitchensis, P. chihuahuana, P. orientalis, P. koyamai, P. asperata, P. maximowicziiand P. likiangensis; P. glauca x P. pungens, P. sitchensis, P. schrenkiana, P. rubens and P. mariana; P. mexicana x P. rubens, P. glauca, P. engelmannii and P. likiangensis; P. sitchensis x P. glauca, P. rubens, P. mariana and P. likiangensis; P. rubens x P. sitchensis, P. glauca, P. orientalis,P. likiangensis, P. maximowiczii and P. koyamai; P. abies x P. asperata. Other crosses are as yet unconfirmed. A small number of tri-hybrids and hybrid backcrosses are being investigated. Transfer of our remarkably heterotic cross, P. rubens x P. omorika, to tree production for mass propagation reforestation purposes has been effected.

In response to many requests for information on flowering in spruce with respect to cone production and budworm attack, an information leaflet was produced jointly with the Great Lakes Forest Research Centre on the identification, growth behaviour and a method for forced flushing of black and white spruce flowers for pre-season evaluation of potential cone crops, budworm damage, etc.

(Gordon)

Cone Induction

The long juvenile growth phase is the main obstacle in advance generation breeding, and irregularity in cone production impedes the breeding programs. This study is designed to promote cone production in white and black spruces and hopefully to overcome the obstacle and the irregularity.

Investigations were carried out in cone induction. In one investigation, gibberellic acid (GA 4/7/9) was applied to white and black spruce in the amount of 100 micrograms per tree per week for 2 to 8 weeks. In the other study, white spruce trees were girdled, root-pruned or both.

GA was effective in inducing pollen and seed cones. After an 8-week treatment, the average seed-cone production increased 6-fold and pollen-cone production 2-fold in white spruce. The increase in black spruce was 4-fold in seed cones and 10-fold in pollen cones. Clones responded differently to GA treatments. Pollen viability and tree height growth were not affected by the treatment.

Root pruning appeared to be better than girdling in promoting cone production. Root pruning resulted in 5-fold increase in seed cones and 1.5-fold in pollen cones over the controls. The response was highly variable by clone. Girdling and a combination of girdling and root pruning were not effective. The treated trees grew more in height than the controls.

The increase in cone production will facilitate breeding and production of improved seeds for regeneration.

Pollination Techniques and Frequency

A study of pollination techniques and frequency was undertaken in order to increase the proportion of filled seed in white and black spruce cones. Brush pollination was 2.5 to 3 times superior to syringe pollination in the production of filled seeds in black spruce based on a controlled pollination including 3 clones and 10 trees per clone.

Four clones of white spruce were used in the study of the effects of subsequent pollinations. By using coloured pollen in controlled pollination, the results indicated that the ovules without any pollen on the nucellus would continue to exude pollination drops to catch pollen and the repeated exudation might have occurred in some of the ovules with

pollen on the nucellus. Based on the filled seeds from a single pollination with live pollen and a combination of pollinations with live and dead pollen, the second pollination appeared to affect very little in the production of filled seeds.

(Ho)

Black Spruce Cone and Seed Yields

For planning purposes, more reliable cone and seed yield and quality data, applicable across northern Ontario are required. Several current studies are showing applicable results. Mean yield of black spruce cones varies from 1 to 5 L per tree. Principal factors influencing yield appear to be year of collection, age of stand, age of cones, size of cones and extraction and cleaning methodology. Individual tree variability is an overriding factor influencing each of the others.

In older stands a yield of 5 L or 2000 cones/tree appears a maximum expectation in a good seed year, thereby requiring 20 trees per hectolitre of cones. This represents seed yields of 35 to 40 g per tree and 40 000 to 60 000 seeds. In a study of over 3000 trees in Northwestern Ontario in 1979, maximum mean yield ranged from 1000 to 1400 cones per tree. In a medium to poor seed year, 1-2 L or 400 to 600 cones per tree appears a more reasonable maximum production. Individual tree variation in one study ranged from 0 to 7 L per tree in a medium seed year in Geraldton in 1979.

Collections from young stands and plantations in 1979, based on selection of trees with a good cone crop, resulted in 1-2 L or 300 to 400 cones per tree. These volumes resulted in 8-20 g of seed or 8000 to 20 000 seeds per tree. Subsequent collections in 1980 and 1981 based on random tree selection have yielded less than a litre per tree. From data analysed to date, young trees produce seed about 25% heavier than those from older trees.

A 3-year study of yield relative to cone age was initiated in 1980 in Geraldton and Sioux Lookout. First-year data indicate a 25% loss in seed between 1980 and 1979 cones collected in 1980. Germinative capacity of sound seed did not vary significantly between cone age classes. However loss of germinative energy, i.e. rate of germination, was indicated due to natural storage in the cone on the tree.

Cone size is a maternal characteristic of the individual tree. A higher proportion of large cones is found on young trees. Seed weight is positively correlated to cone size, varying in one young stand from 1.3 mg for large cones to 0.9 mg per seed from small cones. In older stands cones varied from medium to small with mean seed weights varying from 0.9 to 0.7 mg. Number of seeds per cone was positively correlated to cone size. Number of cones per hectolitre was inversely related to cone size resulting in a more or less constant yield of seed per hectolitre independent of cone size.

Seed yield per cone and hence per hectolitre varied markedly with extraction and cleaning techniques. This could invalidate yield comparisons between studies.

White Spruce Growth Related to Seed Origin

Past studies in white spruce have shown that the mean rate of growth varied with origin of seed. Continuing assessment of older studies will show the magnitude of gain or loss which may be associated with seed distribution policies, while newly established projects will help to delineate population boundaries and provide more comprehensive seed transfer rules.

Analysis of 20- and 25-year-old cooperative provenance trials has suggested that results as early as 5 years from planting may provide reliable information. Early differences are becoming more important as the plantation grows older. Vigorous growth of some southern Ontario origins emphasizes the need to preserve these valuable remnant gene pools.

Seed collection for current regional and all range trials is complete with over 150 collections, most composed of 10 individual trees,

across Ontario. Production of stock for 15 of the 16 experiments planned is complete. Three experiments were established in 1981 in Chapleau, Sudbury and Minden, completing 12 of the experimental sites selected including 4 of 5 all range trials planned.

(Skeates)

White Spruce Gene Pool

Throughout much of southern Ontario, only remnant stands and scattered pockets of white spruce remain. Thus, the gene pool of white spruce has considerably depreciated.

Regional reports outlining the results of surveys in 1980 and 1981, and recommendations for gene pool conservation, have been prepared. The survey findings confirm that white spruce stands number relatively few in the southern districts and are in dire need of conserving.

A pilot project was initiated in conserving gene pools through grafting. Many superior white spruce trees were selected in an area north of Guelph and propagated. This grafted stock will eventually be outplanted in a gene bank. If successful, this program should grow to conserve all valuable concentrations of natural white spruce in the four southern administrative regions.

(vanBorrendam)

Jack Pine

Population Structure

Starch-gel electrophoresis of jack pine megagametophyte tissue was used to estimate genetic variability among 32 stands from eight townships in central Ontario. Of the 27 enzyme loci resolved from 13 enzyme systems, 20 loci were found to have multiple molecular enzyme forms or isoenzymes.

Results indicate that genetic variation, as measured by isoenzyme heterozygosity, is fairly high. Most of this variability can be attributed to individual tree differences within stands. Variability due to differences among townships was estimated to be only 1.5% of the total variability, while differences among stands accounted for 5.2% of total variability.

Isoenzyme data suggest that site region 4E jack pine in the Blind River district may be part of a breeding population which includes site region 3E jack pine in the southern part of the Chapleau district. If this is verified by growth and yield information, independent jack pine tree improvement programs in each site region may be able to exchange promising materials or even share improved seed from common seed orchards.

(Buchert)

Wood Quality

The variation in wood quality of jack pine in Ontario was studied in cooperation with Dr John Balatinecz, Faculty of Forestry, University of Toronto. Preliminary analysis of wood character data from breast height discs of 310 jack pine trees indicated that both tracheid length and specific gravity are highly variable between trees, and that in general, both characters increase with age. A detailed analysis of 93 trees gave the following range of individual tree values for different ages:

	Specific gravity
0-10	years = 0.318 - 0.472
11-20	years = 0.331 - 0.477
21-30	years = 0.350 - 0.544

	Tracheid length
pith	= 0.90 - 1.90 mm
10	years = 1.78 - 2.89 mm
20	years = 2.03 - 3.22 mm
30	years = 2.18 - 4.02 mm

These preliminary results suggest that both tracheid length and specific gravity of regeneration stock can be manipulated by screening and selection of parent trees.

(Buchert and Balatinecz)

Pitch Pine

A gene pool conservation survey of Ontario pitch pine, was conducted by Mr Craig Witzke, Lansdowne, Ontario. A total of 186 pitch pine locations have been mapped and surveyed for stand size, reproductive vigor, stand

condition, site information and individual tree information. Many known stands are stable, some are expanding in size and some are shrinking or have disappeared. This initial survey will provide management information on how best to conserve this unique gene pool of pitch pine, in addition to providing location information of stands containing superior phenotypes useful in pitch x loblolly hybridization work.

(Buchert and Witzke)

White Pine

Breeding

The purpose of white pine breeding at the Institute is to secure genetically improved, blister-rust resistant sources of white pine for Ontario's plantation program. The project aims also at developing clonal stock of hybrid white pines for fast growing, intensively managed plantations.

Hybridization

In 1981, 57 crosses were attempted in combinations such as P. griffithii McClelland x strobus L., P. griffithii x (peuce Griseb x strobus), P. griffithii x cembra L. v. sibirica Loud, P. peuce x pumila Reg., P. strobus x cembra v. sibirica, P. strobus x peuce, P. strobus x pumila, P. (monticola Lamb. x peuce) x strobus.

Progeny Trials

To date, open-pollinated progenies from 85 plus trees have been included into 6 progeny trials. Of these, 2 are already outplanted, 3 are in nursery-transplant stage, and one is in the greenhouse. The goal is to single out the best combiner parent trees and to identify superior progenies. Results indicate very significant differences in progeny performance. Seeds of best progenies were provided to Forest Management for production trials.

(Zsuffa)

Blister Rust Resistance

A study of protein patterns in needles of blister rust resistant and susceptible clones was contracted with Dr M. Hubbes, Faculty of Forestry Univer[illegible]y of Toronto. Needle samples w[illegible] taken during the growing season fr[illegible] trees inoculated and free of disease. Early results suggest quantitative and qualitative differences in needle proteins of resistant and susceptible clones.

A review of experiences concluded that the blister rust resistance of P. strobus is of polygenic nature. Artificially inoculated F_1 progenies succumbed in large numbers and gave no indication of parent trees producing progenies with increased blister rust resistance. Field tests of F_1 progenies indicated higher levels of blister rust tolerance and mother trees with ability to produce blister rust tolerant progenies.

(Zsuffa and Hubbes)

Larch

Combined performance trials and breeding arboreta of Larix gemlini were planted in the spring in the Lindsay, Fort Frances, Ottawa and Espanola Districts. Survival of the 16 to 18 seed lots (per plantation) was good at all but the Espanola site. An additional larch trial containing a number of species and interspecific hybrids was established in the Huronia district. Seed lots included L. decidua, L. laricina x L. decidua, L. leptolepis, L. decidua x L. korilensis, L. decidua x L. leptolepis, and the reciprocal, and L. orientalis.

(Hood)

Black Walnut and White Ash

To reflect the increasing interest in hardwood plantation establishment, and in particular with such species as black walnut (Juglans nigra) and white ash (Fraxinus americana), an Ontario range-wide inventory of superior phenotypes and populations is being compiled from which a breeding population can be established for the future genetic improvement of these species.

The high value and selective cutting of superior black walnut stems may be having a deleterious effect on the gene pool of this species. Since

outstanding timber-types of black walnut are now a rarity in Ontario an effort is being made to preserve the gene pool by grafting selected clones for inclusion in a breeding arboretum from which future clonal seed orchards will be established.

The grafting of selected black walnut trees began at the Institute greenhouses in 1981 and continued during the spring of 1982. The grafted ramets of these clones will be outplanted in a clonal gene bank near London, Ontario during 1982.

A fast-growing, fertile, walnut hybrid called the Buartnut was discovered in Southern Ontario in 1981. This hybrid is a naturally occurring cross between the Japanese heartnut Juglans ailantifolia and our native butternut Juglans cinerea. This hybrid appears able to exploit the poorer, drier, sandy sites which are too infertile to support good black walnut growth; and it appears to be as cold hardy as our native butternut.

During the summer of 1981 a survey was conducted for the location of phenotypically superior populations of white ash on crown land and in hardwood woodlots under the Woodlands Improvement Act agreements.

(Mosseler)

Tissue Culture

A rapid method for propagation of poplar and white spruce by tissue culture is being developed. Large numbers of rooted plants can be rapidly formed from small explants. This technique is also useful as a method for international exchange of material under sterile conditions to eliminate the danger of disease introduction.

Poplar and Willow

Sections 1 mm thick of growing shoots and 1 mm long sections of growing leaves of Populus nigra were incubated at 27°C and 16 hour photoperiod. After 40 days callus developed from cambial cells of the stem and mesophyll cells of the leaf piece. When the callus grew profusely and turned green, it was transferred to another media (1/2 NS + 0.1% BAP + 0.1% NAA) where organogenesis occurred. When the plantlets were 2-3 cm in size, they were transferred to a rooting media of 1/2 MS (Murashige and Skoog) + 0.02% NAA where the roots developed in 10 days. When the plantlets were 4-5 cm in length with a good root system they were transferred to pots.

The same method was followed in overwintering buds in three species of Populus, and 4 clones and S. grandidentata. Only S. alba developed good callus; the other species did not respond to this method. Diploidization of haploid plants is the method to procure isogenic pure lines for breeding to exploit non-additive genetic effects. Poplar is dioecious and the pure lines are not attainable through sexual reproduction. Anther or isolated pollen culture is the technique to obtain haploid plants. Anthers of 7 poplar clones were cultured on Murashige and Skoog (MS) medium containing 2 mg/l of 2,4-D and 1 mg/l of kinetin when pollen was at the mononucleate stage prior to mitosis. About 40 days later, callus developed in the anther cavity. The callus was transferred to another MS medium containing 1 mg/l of BAP and 0.2 mg/l of NAA for organogenesis when the callus grew to about 5 mm. Adventitious shoots regenerated from the callus in 3 months. Shoots about 3-cm long were separated from the callus and planted in a rooting medium containing 1/2 MS medium plus 0.02 mg/l of NAA. Plantlets were produced in Populus maximowiczii x deltoides; their ploidy level still has to be verified. The production of isogenic pure lines will facilitate isolation of genetic variants and capture the heterosis through breeding.

(Raj and Ho)

Spruce

Seeds of white spruce were germinated in sterile sand. The cotyledons were cut into 1 mm segments and incubated in media (1/2 MS + .01% BAP + .01% NAA) at two stages of germination and two different parts of seedlings: 1/ just at the emergence of cotyledons, 2/ after cotyledons were fully expanded, 3/ crown region and 4/ coleoptile. The crown region and fully expanded cotyledons were found to be the right stages for

incubation, because callus developed profusely and much earlier than the other two. Callus developed in 2 months and it was transferred to media without any hormones where multiple buds developed. The shoots were severed and transferred to rooting media. Not much success was achieved in rooting the seedlings. Various hormones are being tried.

(Raj)

PRODUCTION AND PERFORMANCE OF CONIFEROUS PLANTING STOCK

Physiology and Morphology

Dormancy and Frost Hardiness

It is important to be able to determine the state of dormancy in nursery stock because the best time for moving stock for overwintering storage and/or outplanting is when the stock is fully dormant. When we have achieved this ability to determine dormancy we will be able to increase survival and subsequent growth after outplanting.

Two approaches are being tested, one is physical and the other is chemical. The physical approach involves electrical impedance, which has been tested for several years. As has been stated (Forest Research 80), "impedance trends reflect the stage of dormancy and frost hardiness to some degree but further refinement of this technique is needed". Presently we are working on this refinement, by subjecting 6 years of impedance data to multivariate analyses to come up with a simple-to-use dormancy prediction formula. The results of these analyses should be available by late 1982.

The chemical technique involves the monitoring of the seasonal patterns of amino acids within the seedlings. Extraction procedures have been standardized and by the end of 1982 it is expected that the important amino acids will have been identified and that some of their seasonal fluctuation in concentrations will have been determined.

(Glerum)

Bud Development in Jack Pine

Bud development in first-year jack pine is not necessarily an indicator of potential second-year height growth. The initial flush of height growth is mainly the result of the extension of internodes between the needles of the rosette below the terminal bud. This mode of height growth appears to be unique to the pines in comparison to the other North American tree genera, and was studied in detail for jack pine. Studies have shown that approximately 90% of second-year height growth (excluding lammas growth) resulted from extension of the rosette. Only 10% or less of the growth originated from the terminal bud. Fascicle shoots arose from axillary buds located in the axils of the primary needles of the rosette as well as in the axils of budscales in the terminal bud.

An understanding of the mode of height growth in pine seedlings is important for nurserymen raising container stock so that treatments affecting rosette development can be identified. Studies are now being conducted to identify factors which promote the development of rosettes containing large numbers of primary needles, with the aim of increasing second-year height growth, in the same manner as buds in spruce which contain large numbers of needle primordia.

Some environmental factors affecting terminal bud and rosette formation in jack pine are now being studied. Under warm, short-day conditions, seedlings formed large terminal buds with brown budscales. Buds which formed under operational conditions (cool temperatures and naturally declining daylengths) could only be seen upon dissection, and are made up of small, fleshy, more needle-like budscales. Seedlings exposed to short days at 5°C formed no budscales at all, as activity at the shoot apex was apparently suspended under these conditions. The effect of these environmental conditions on rosette formation is now being analyzed.

Effect of Fertilizer Regimes on Bud Development

Bud development was examined in a study carried out by Mr W.A. Smith of the Swastika Tree Nursery. This study was to determine the effects of fertilizer concentration on growth and bud development of jack pine and black spruce container seedlings grown in three types of media (local peat moss, local peat moss with vermiculite, or a commercial brand of peat moss with vermiculite).

In black spruce grown in commercial peat and vermiculite, the optimum fertilizer rate for height, dry weight and stem diameter was between the normal rate of application and the rate 3 times greater than the operational level. In local peat with vermiculite the optimum rate was 3 to 9 times the operational rate. Bud development (number of needle primordia) was greatest at a rate 9 times greater than the operational level, because height growth stopped and buds set early as a result of salt stress, so that these seedlings had large numbers of needle primordia. Numbers of needle primordia were otherwise greatest for the fertilizer level producing the greatest diameter seedlings.

In jack pine, the optimum fertilizer level was between 3 and 9 times greater than the operational rate, as reflected by trends in seedling size. Number of needles in the rosette and number of budscales were similarly related to fertilizer level.

In both black spruce and jack pine the optimum fertilizer rate was unaffected by growing media type, although at lower rates of application (no fertilizer or 1/3 operational rate) height, dry weight and diameter in both species were greatest in the commercial peat moss with vermiculite.

Improving Quality of Container Stock

Under current production techniques for overwintering black and white spruce container seedlings, the stock is moved outside in August, at which time height growth has not as yet ceased, bud development has just begun and the seedlings are susceptible to damage by freezing temperatures. In this study at one nursery, shoot tip mortality in black spruce averaged 30%, while in 1981 an average of 12% of the black spruce shoot tips were killed by frost. This problem is serious because not only will the seedling be lacking a dominant terminal shoot for several years, but outplanting success using damaged stock will likely be reduced as a study has shown that seedlings with dead terminals suffered a 40% reduction in root growth capacity.

In addition to damage caused by fall frost, bud development is severely reduced under current production schedules. Under ideal conditions of warm temperatures (20 to 30°C) and short days (8 to 14 h), we have found that nearly 300 needle primordia will form in terminal buds. Current cultural practices, however, place seedlings outside just as bud development is beginning, with the result that buds formed under cool temperatures out-of-doors, contain an average of less than 100 needle primordia. This reduction in bud development will result in reduced growth following outplanting. The reduced photosynthetic area, because of fewer needles, could result in long-term growth losses.

Thus, new production techniques to prepare seedlings for overwintering have been investigated in the past year, to establish their effectiveness at promoting the development of buds containing large numbers of needle primordia while concurrently allowing cold hardiness to increase without the risk of damage by fall frosts. Two techniques were tested: both used the warm temperatures in the greenhouse to keep temperatures in the optimal range for bud development. Short daylengths were in one case artificially produced, using shades in July and August before the seedlings were moved outside with the production run stock, while in the other method a period of extended greenhouse culture was employed to allow exposure to naturally shortening daylengths.

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Using artificial short days, an average of 140 needle primordia formed before bud development was curtailed by low temperatures. An

average of only 68 primordia formed in the buds of production run stock. Terminal buds of extended greenhouse culture seedlings produced an average 270 needle primordia, an increase in almost 400% over production run seedlings.

Cold hardiness, determined by artificial freezing tests, was low throughout August in all stock types, but in the first two weeks of September there was a dramatic increase in cold hardiness of short-day treated seedlings. There were comparable increases in cold hardiness in production run and extended greenhouse stock, but these increases occurred two weeks later. A damaging frost on September 23rd resulted in about 9% shoot tip damage in production run stock, but there was no damage in either the extended-run greenhouse seedlings after they were finally moved outside (October 28) or in the short-day seedlings, presumably because cold hardiness had increased sufficiently before exposure to freezing temperatures.

(Colombo)

Accelerated Transplants

A black spruce container transplant study, initiated in 1980, was completed. Past projects demonstrated the feasibility of the Dewa block system for operational production of bare-root transplants in northern nurseries on a 2-year rotation. This study provided additional knowledge on optimum growing media to be used, and compared the system to paper pot and bareroot 'Finn-house' seedlings. Associated with the study were comparisons of pregerminated versus naked seed and shelter versus greenhouse initiation of seedlings for transplanting.

The study showed that each of the three systems could be used to produce stock with acceptable mean values of root collar diameter and oven dry weight, depending on growing media selected. Winter kill of first year leaders prevented stock from reaching expected two-year heights.

Paper pot seedlings grew to acceptable transplant quality irrespective of growing media in the greenhouse phase. Performance of transplants initiated in Dewa blocks was influenced by differences in soil compaction, hence aeration. Similar compaction occurred in trays of bare-root seedlings as a result of settling due to irrigation. Loading of soil in trays for bare-root and paper pot seedling production was similar. However the containers in the latter case provided vertical support for the soil and wicking enhanced aeration. Dewa blocks and bare-root seedlings, started in Swastika peat, were of poor quality. Those started in sphagnum/vermiculite and peat/sphagnum soils performed best.

Handling at time of transplanting was difficult for paper pots and Dewa blocks with some soils. Lack of soil stability did not result in appreciable transplanting shock for seedlings in sphagnum/vermiculite soils in either system or in peat/perlite soil in paper pots as evidenced by subsequent growth in the nursery. Mechanization in these instances would appear to be impractical.

Within each system a relationship was shown between size of stock at time of transplanting and size of 1-year-old trees with approximately 4- to 6-fold increase in oven dry weight. Weight of 2-year-old plants was correlated to oven dry weight at the end of the first year with approximately a 9-fold increase.

In the first season in the nursery beds, bare-root seedlings, started in 4 of the 5 soils, grew more slowly than the container grown seedlings. Stock initiated in sphagnum/vermiculite soil achieved a size comparable to that of paper pot initiated plants. Two-year transplants, started in sphagnum/vermiculite and peat/sphagnum cubes outperformed paper pot and bare-root initiated transplants. Dewa block and bare-root seedlings, being smaller at time of transplanting, remained the poorest performers through a year and a half in the nursery.

Transplants from pregerminated seed in Dewa blocks outperformed those from seed. Transplants from pregerminated seed in blocks placed in unheated insulated shelters performed well, indicating the possibility of reducing dependence on

greenhouses. High density mini-container systems for early transplanting of advanced pre-germinants are being investigated.

A feasibility study is in process as a basis for automating transplant systems for accelerated transplants. Further studies with pre-germination techniques and mini-containers could significantly reduce duration of greenhouse operating time with savings in labour and energy costs. High yield mini-container systems also have the potential for drastic reduction in greenhouse space required hence capital costs of greenhouse construction.

(Skeates)

Overwinter Storage

Frozen overwinter storage of packaged shipping stock of some species has been an accepted practice at most Ontario nurseries for several years. Second-year results, however, of 3+0 white pine (Pinus strobus) for St. Williams Nursery, the most southerly in the province, indicated that cool storage (1°C) may be more suitable than frozen storage (-3°C) for overwinter holding. Analyses of the 7 weekly lifts from October 18 to December 1, 1977, resulted in cool storage having the advantage over frozen storage in 18 of the 21 survival comparisons and in 17 of 21 growth comparisons. Further trials are currently being conducted to confirm the results. Overwinter storage trials of European larch (Larix decidua), Japanese larch (L. leptolepsis) and tamarack (L. laricina), using late fall lifts during 1976-1979, showed no significant differences between stored and fresh springlifted stock with respect to survival, height or terminal growth after 2-5 years under outplanted field conditions. Due to the early season growth characteristics of all these species, the nurseryman now has the option of fall lifting to avoid springtime lifting pressures.

Five years after outplanting, a trial using 2+0 jack pine (Pinus banksiana) from Swastika Nursery showed lifting and dry packaging (no water dipping and no moss) to be as successful as other treatments (water dip, moss, or both) for frozen overwinter storage in Kraft-polyethylene bags. One year later, a similar study using black spruce (Picea mariana) from the same nursery provided similar data after 5 years. These results give additional support to other species and location studies that showed water dipping and/or use of sphagnum moss to be unnecessary for frozen overwinter storage.

The Dunemann Process

The original process was developed in Germany as a method of producing large quantities of good quality nursery stock on a limited land area in 50 cm deep beds of organic matter -- usually duff from conifer plantations. On a continuing basis since 1976, the feasibility of using the same process to produce 2+0 white pine (Pinus strobus), Norway spruce (Picea abies), red pine (Pinus resinosa), and white spruce (Picea glauca) has been investigated at the Midhurst research area. Sowing rates have been approximately 600, 1300, 1500 and 1700 viable seeds per square metre respectively. There were no applications of herbicides, insecticides or fertilizers. Irrigation was used each year until late September but only when weekly rainfalls were below 2.5 cm. The stock produced was then used in follow-up trials: rising 2+0 late summer transplanting with additional field planting at the 2+2 year; 2+0 fall field planting; 2+0 spring field planting using both overwintered frozen and fresh spring lifted stock. All follow-up trials included regular bare-root nursery stock for comparison purposes. The results are summarized in Nursery Note No. 73 (see Publications).

(Hutchison and Racey -- Mullin)

Effect of Stock Type

Container Versus Bare-Rooted Stock

Jack pine overwintered in Japanese paper pots and in Spencer-Lemaire containers were outplanted with bare-root stock in the Wawa district on a fresh and dry site during the spring of 1979. The purpose of the planting was to test the container stock and determine to what extent site

differences influence survival and subsequent growth. To extend the planting season the plantings were spread over a month by having 3 plantings which were 2 weeks apart. Some spring-sown jack pine in Japanese paper pots were also planted in the third planting.

Third year results suggest that 1/ survival of bare-root stock was significantly less than container stock on both sites, 2/ initial height differences between bare-root and container stock at time of planting remained significant on the dry site but were non-significant after the third growing season on the fresh site, 3/ site differences have a significant effect on total height of container stock but this difference became noticeable only during the third growing season, 4/ planting delays did not have a significant effect on survival but height was significantly reduced between the first and third planting, and 5/ survival differences between overwintered and spring-sown stock were not significant and the latter has a one-year lag in growth as compared to the former when planted in the same year.

Seedlings Versus Transplants

Red pine age classes 3+0, 1+2 and 2+1 (Orono only) and 2+2 from Orono and Midhurst Nurseries were outplanted at Vivian and Larose forests. The purpose of the plantings was 1/ to see if other age classes of red pine showed similar growth development and performance as the 3+0 age classes commonly used, and 2/ to test the 1+2 age class, which is a new red pine age class. The significantly better performance of the 1+2 and 2+2 transplants observed at both outplanting locations in the first 3 years after outplanting suggest that the 1+2 is a viable age-class alternative as a transplant. Monitoring will continue.

A similar experiment using white pine outplanted on 5 different sites showed that at the end of the second year 1+2 stock was best, 2+2 next, then 2+1 and 3+0.

(Glerum)

Irregular Growth of Outplanted Red Pine

This study was established in 1976 to determine whether nursery stock quality or handling and planting procedure was responsible for the irregular growth of red pine which had been observed in a number of field plantings. The performance of regular 3+0 red pine nursery stock, handled from the nursery and planted in the field with reasonable care by research staff, was tested and compared with the performance of similar stock handled and planted during normal district operations. Fifth-year survival, height increment, total height and aggregate height data of the research and district planted stock were analysed and reported on during 1981. Some relationships between seedling quality after the first and second years in the field and subsequent growth to the fifth year were also explored. The study which is now completed and reported, has indicated that 1/ nursery stock of the quality provided could survive and grow satisfactorily in the chosen planting sites when handled and planted with reasonable care, 2/ the handling and planting procedures in use in field operations in 1976 did have a negative effect on both survival and growth, even after five years, and 3/ early monitoring of seedling quality as well as survival is useful in forecasting the future development and success of plantations.

(Pierpoint and Glerum)

Planting Quality

Guidelines to tree planting quality have, for many years, been used to control tree planting faults that may occur during the operational tree planting process. Six common planting faults are currently recognized and have been thought to be detrimental to plantation growth and survival if not controlled. These suspected faults are: 1/ microsite: trees planted on rotten logs or stumps, in gulley bottoms or depressions subject to flooding, on cut banks, roadside fill, raised humps of loose soil or debris, or on compacted surfaces such as landing or

skidways; 2/ scalping: trees planted in debris such as duff, rotten wood, loose rock, sod, or minor vegetation that has not been removed down to a suitable soil layer; 3/ planting hole: trees planted in planting holes that are not suitably prepared so that the entire root system of the tree is not in as natural a position as possible; 4/ tree placement: includes trees planted deeply with 2-3 cm of green needles or branches covered by soil, exposed roots, balled, bunched or tangled roots, and trees planted with a portion of the tree exposed below the root collar; 5/ firmness: trees planted loosely, insufficient compaction; and 6/ position: trees planted so that the stem is not within 30° of a vertical position or planted such that its crown is obstructed by slash or competing vegetation.

Continuing surveys in the North Central Region show, as one might expect, that trees with planting faults show higher levels of mortality than those without observable defect. Highest mortality generally occurred on loosely planted trees and trees planted with a combination of two or more faults, regardless of species. Higher than expected mortality was also evident on trees planted with inadequate scalping and with exposed roots. Mortality trends, as reported above, are evident in the first year after outplanting when greatest mortality occurs. Subsequent years show only slight increases.

Growth responses to planting faults are varied and not readily related, at least in the early establishment years. Slight reduction in current annual height increment occurred in the second and third year of growth after outplanting for trees with planting faults. This reduction in height increment is most noteworthy on loosely planted spruces and for jack pine planted with multiple faults. It is as yet unclear whether any or all of the planting faults will significantly reduce growth in the long term. As the assessment is continuing, it is hoped that a better determination of planting fault effects on survivor growth can be made.

Recognition and avoidance of planting faults known to adversely influence survival and/or growth of bare root planted stock can be an aid in the achievement of plantation performance goals.

(MacMillan)

Root Growth

Assessment of conifer planting stock quality is commonly undertaken by means of quantifying root growth capacity at a specific time during processing prior to planting. The time interval employed for the test period varies but there have been attempts to correlate root growth activity over short periods of time to performance potential. There is, however, the question as to just how much root development occurs over extended periods. This is important particularly when planting is contemplated just prior to expected or normally dry periods. Furthermore, lifting of planting stock in the spring over extended periods of time may affect root growth capacity and if this capacity is diminished because of late planting its affect on post planting performance is yet undefined.

Answers to these questions are expected to be obtained from a nursery-greenhouse-field trial initiated in May 1981. Black spruce 1 +1 stock was lifted on 2 occasions 2 weeks apart and placed in cool storage. At bimonthly intervals sufficient seedlings were removed from storage and either field planted or potted in the greenhouse for assessment of root growth. Field performance (survival) of trees was monitored bimonthly and root growth of potted trees was examined at 21, 42 and 63 day intervals. Performance of experimental trees was compared with that of freshly lifted trees. Although data are yet incompletely analyzed it appears as if under favourable growing conditions root systems double in size after about 6 weeks. This applies both to freshly lifted black spruce stock and to early spring lifted (e.g. May 12) and cool stored stock with up to 6 weeks of storage. For later spring lifted, e.g. May 24, and cool stored trees and after 4 weeks of storage, vigor in root growth diminished, requiring up to 7-8 weeks after planting to double root size. No variations in

tree survival related to time of lift or length of storage were detected in the fall assessment. The inference could be made that black spruce possesses a degree of tolerance to various handling and storage regimes. This possibility will be further explored with continued monitoring of field plantings.

(McClain)

STAND MANAGEMENT AND PRODUCTIVITY

Productivity and Nutrient Cycling in Spruce Forest Ecosystems

Nutrient capital and the rate at which nutrients cycle in forest sites have become of increasing concern in forest management. Until recently, manipulation of rotation ages, the form of harvesting and subsequent site preparation have primarily been related to maximizing extractable timber, improving economic and silvicultural aspects of harvesting and subsequent restocking. An understanding of the constraints exerted by nutrient levels and their behaviour in the nutrient cycle on different sites and under differing harvesting regimes is critical to forest management planning.

Studies undertaken in this program show the tremendous differences that exist between the organic matter, nutrient capital and resilience of various sites, and the response to differing harvesting prescriptions. For example, in black spruce stands on typical outwash sand and peat landtypes, more than half of the total organic matter pool is in the standing crop. Full-tree logging results in the removal of an amount of organic matter in excess of 100% of the organic reserves of those sites. In contrast, average boreal mixedwood sites (white spruce, balsam fir, trembling aspen and white birch) carry a standing crop representing less than 100% and often more nearly 50% of the soil organic reserves, or about one half to only one third in favourable circumstances, of the total organic pool of such sites.

Nutrient losses in standing crop removal in full-tree logging, as a percentage of nutrient reserves in the organic and mineral rooting zone of the soil are a measure of depletion and are of great importance. Nitrogen which is frequently in short supply for optimum growth is usually in fair supply relative to reserves. Only 28 and 40% are lost for black spruce on outwash and peat, respectively. For boreal mixedwood, losses are still less at 7%. Potassium losses however are critical. For black spruce, 348% on outwash and 397% on peat or amounts equivalent to 3 or 4 times that which is in the soil reserves. For boreal mixedwood, the losses are much less critical. For average stands, losses may be as low as 28% of the reserves. Similarly, phosphorus losses for black spruce are critical on outwash, 272%; and on peat, 296% of reserves. Phosphorus losses at 84% of reserves may also be approaching critical levels on boreal mixedwood sites. Calcium and magnesium losses are excessive on outwash but seem sustainable on peat and mixedwood sites.

Dynamic and nutrient cycling studies enable measurement of both the more complex internal as well as the simpler external input components. It is possible from these to calculate reasonable replacement times for any nutrient element. In the case of full-tree logged black spruce, replacement times for most elements do not seem too excessive, being usually under 25 years. Only for potassium, are values indicative of problems. It will take up to 42 years on outwash profiles and 31 years on peat for potassium levels to return to pre-cut levels. Values for some outwash stands are for over half a century. However, for boreal mixedwood, average values are generally twenty years or less. If, instead of full-tree logging, biomass harvesting, where tree roots, stump axes and all organic matter from subordinate vegetation had been included in the harvest, reserves would have been reduced still further, and replacement times increased substantially. This would result in a further additional increase in rotation age.

(Gordon)

Growth and Yield

Red Pine Plantations

The oldest red pine plantations in southern Ontario were created over 50 years ago and many more are now approaching that age, the age at which the traditional site index is determined for forest stands. Growth records of the stands have been kept for the last 25-30 years. The time is now opportune to assess the yields obtained from these plantations under different levels of management.

Permanent growth plots, which were established at the time of first thinning and across a variety of forest sites form the basis for this assessment. The growth taking place in a sample stand after a thinning and up to the time of the next measurement was taken as a single observation. Most of the sample plots which had not been checked in the last two years were remeasured during 1981. Only one set of plots in Larose Forest, Eastern Region, was missed since the plantation had been clear-cut. The new data increased the total number of periodic observations from 251 to 348.

All of this information was included in an analysis of the stand components most likely to affect future periodic growth. The analysis took the form of stepwise multiple regression following procedures undertaken by Prof. V.G. Smith (Faculty of Forestry, Toronto) who used the earlier more limited data set.

First, a new table indicating the site index of a plantation, given the dominant height and age from planting, was produced. Secondly, for the control plots which represent unthinned situations, a complete normal yield table was developed showing stand parameters on different sites and at each 5-year interval from 20-60 years. Finally for plantations which have been thinned, 8 sets of growth and yield tables were produced. Each set contains tables for a particular site index at 2 m intervals from 16 m to 26 m (also at 5-ft intervals from 60 ft to 85 ft). Within each set, single tables represent stand situations at 5-year intervals, again from 20 to 60 years from planting. Each table sets out the 5-year growth in basal area and total volume estimated to result from 0% to 50% thinning in stands of variable initial density at the start of the growth period.

These tables, available on request, can be used directly in the field to assess the yield potential of stands undergoing different thinning schedules. Foresters or technicians need only to obtain an estimate of stand dominant height and total basal area. For the known age and desired percent thinning they can readily interpolate the periodic growth to be expected and the yield at the end of the period. The process can be repeated following a prescribed thinning program for succeeding 5-year periods. An important feature of the tables is that the summation of tabular growth over a series of 5-year periods is compatible with the overall production as obtained from the yield equation.

The tables are applicable to row-thinned plantations as well as those given selection thinning. The data base also includes a range of planting spacings from 1.67 m x 1.67 m (5.5 ft x 5.5 ft) to 2.29 m x 2.29 m (7.5 ft x 7.5 ft). The ability to make accurate estimates beyond the sampled ages will be checked as future measurements or other sample areas become available. For instance, the sixth measurement and thinning of a red pine spacing experiment in Huronia District was completed in the winter 1981-82. The actual growth between the fifth and sixth measurements will be checked for accuracy against the growth estimates given in the tables. Growth data from three fertilizer experiments in red pine plantations will become available in 1982 which can also be checked against tabular estimates.

(Beckwith)

Spruce and Jack Pine Plantations

The numbers of conifer plantations in northern Ontario are increasing to meet the forecast demand for wood fibre. There is some indication from the older plantations that their yield per unit area will outstrip the

production recorded in natural stand yield tables, given full stocking. Earlier plantations were often established on good sites, many of which had been cleared for pasture. Those planted in the last 10 years may be on less productive sites and in more normal cutover situations.

The objective of this study is to determine the early rates of growth of spruce and jack pine plantations and to relate these to yields of the resulting managed stands.

Preliminary sampling of individual tree growth was accomplished in several of the spruce plantations and the younger jack pine. Annual height growth was measured as the most significant parameter for later stand dynamics. Diameter measurements within each internode were also taken to enable the development of stem volume tables.

It is too soon to assess the yield-site relationships of plantations in northern Ontario. However, the jack pine stem analysis data, showed that early growth rate (0-10 years) is instrumental in determining the site class into which a young stand may develop.

As more of the common site preparation and post planting treatments (herbicides, clearings, etc.) are sampled with permanent plots, it will be possible to quantify their influence on the critical early plantation growth. As the stands age, experimental thinnings, nutrient trials, etc. may readily be superimposed on the basic yield study areas. A unique example of such thinning work in jack pine is available at Hendrie Forest, Huronia District. Growth tables related to different density regimes were produced from that data during the year which should find applicability in northern Ontario. Such correlations of site and silvicultural treatments with plantation yields will assist in the adjustment of mean annual increments - a salient factor in the new Forest Management Agreement.

(Beckwith)

Balsam Fir

Harvesting patterns and ecological factors are causing a steady increase in the area of the boreal mixedwood forest dominated by balsam fir. The growth of existing fir stands has stagnated through lack of management, and this condition often invites serious stem and root decay. Although more fir will be used to meet the demand for conifer fibre in the near future, there is very little local information on its volume yield and decay relationships. The objectives of this study are to predict the yield of unmanaged fir stands in relation to site conditions, including branchwood volumes for total above ground woody biomass, and to determine the effect of basal decay on growth rate. Benefits to management should include wider utilization and improved quality and yield from currently degraded fir stands on productive mixedwood sites.

Fourteen temporary plots 0.04 ha in size were measured over a range of soil types in the North Central Region. Destructive sampling was included to permit stand back-projection, the determination of branchwood volumes, and analysis of basal decay. The data base of 1430 trees is sufficient for the development of local yield equations for balsam fir.

Final yield tables must await one more sampling season. An early result with management implications is that the volume growth rate of fir on mixedwood sites is highly dependent on stand density, but only weakly related to soil type. Early harvesting for biomass may be a solution to growth stagnation, especially where the spruce budworm is a threat. For whole-tree chipping operations the volume potential of branchwood is significant, amounting to about eight percent of the total tree volume for dominant trees. Basal decay (an indirect measure of root rot) affects current cull percent, but no strong effect on current volume increment could be determined. A pathological rotation age of 60 years is recommended for balsam fir on mixedwood sites.

(MacDonald)

Boreal Mixedwood Succession

Foresters need quantitative information on natural successional trends within the boreal mixedwood to

concentrate their artificial regeneration efforts on the most receptive sites. Resistant sites could be managed for natural mixedwoods. This study relates the pattern of succession to site type and stand history, and will produce mixedwood stocking standards for both untreated and planted sites.

During the first year of sampling, 315 milacre plots were established on sandy loam mixedwood sites near Lake Nipigon. Five disturbance types were covered by 250 of the plots: 1/ cutover without scarification, 2/ cutover with scarification, 3/ light wildfire, 4/ intense wildfire, and 5/ girdling to simulate the effect of fire on the canopy only. Sixty-five plots were placed in undisturbed stands for controls.

One year after disturbance the cutover site was dominated by aspen, which completely and rapidly overcame all black spruce and balsam fir regeneration. Scarification did not change the relative competitive position of each species, but it was associated with reduced height growth of aspen. Trends one year after wildfire depended largely on the burn intensity (as measured by duff reduction). The dominant species following the light burn were aspen, balsam fir and white birch. The intense burn resulted in complete dominance of the site by aspen, which suckered from roots. The dominance of competing shrub species was promoted by the light burn, but significantly reduced by the intense burn. An understanding of the control of succession by disturbance type on various mixedwood sites will assist management in making the optimum regeneration prescriptions.

(MacDonald)

Conifer-Hardwood Plantations

The primary factors responsible for the failures in regenerating red oak naturally in Southern Ontario are severe pilferage of acorns by rodents and browsing of young trees by deer and rabbits. Planting of red oak nursery stock with pine as a nurse crop seems a good method of replenishing the once more-abundant oak in Ontario. The 34-year-old red pine-red oak plantation in the Huronia District, probably the only in Ontario, is a successful example (see Forest Research Note No. 17, 1978). Growth data are now available after the first and second thinnings, growth periods 1970-75 and 1976-81.

The average total height of oak was always better than that of pine by 1.5 m up to the first thinning. The periodic increments were 1.4 m for oak and 1.0 m for pine after each thinning.

The average diameter of pine was better than that of oak by 3.5 cm before the first thinning. The periodic increments were 0.8 cm for pine and 1.6 cm for oak after the first thinning and 1.1 cm and 1.7 cm, respectively, after the second thinning. Best increments of 1.4 cm and 2.25 cm were produced by dominant pines and dominant oaks, respectively, after the second thinning.

By 1981, the average merchantable bole length of oak was 9.3 m (30.5 ft). The proportion of the bole length to tree height was better in the intermediate crown class than the dominant class, 67% vs. 58%. Pruning of all dry and green branches on oak stems, including high forks as part of the main crown but excluding epicormic branches, was carried out in 1979. The number of oaks with epicormic branches increased from an average of 19% in 1975 to 81% in 1981. Pruning, crown vigour and exposure of stems to light has likely caused the increase in the number of trees with epicormic branches. In addition, red oak is known to be inherently more susceptible to develop epicormic branches than, for instance, white ash. However, as crowns of oaks expand, epicormic branches should gradually succumb.

During future selective thinnings, some pine should produce poles. The rest should be left to serve as trainers until their complete suppression by oak. Some oaks, including dominant ones, should produce small size logs before the final harvest of oak at about age 120 years. By this time, several alternatives should be available to establish a regeneration in advance of the final cutting.

The monetary returns and

utilization of quality hardwood veneer has remained high, and therefore its production should be encouraged wherever possible. The economic importance of oak should show up primarily in the production of veneer wood.

Based on the success of this red pine-red oak plantation, a 3-ha experimental planting of the same mixture was established in 1981 in the Huronia District.

(Stroempl)

Thinning Tolerant Hardwoods

The tolerant hardwood stands of southern Ontario have received a wide variety of silvicultural treatments from clear-cutting to individual tree selection. This variability in cutting has led to stands ranging from even-aged to uneven aged situations and from stands containing many individual high quality stems to stands of residual poor quality, the latter a result of high-grading. All of these stands require two or more improvement cuts to upgrade stem quality and to create a desirable diameter distribution. Thus cutting history as well as species composition and site complicate the management of hardwood forests in southern Ontario. Our purpose is to integrate these factors with pre-selected thinning levels. This will help set the optimal cutting prescription for management practice. This assessment of our hardwood stands is as complicated as their management.

Over 300 permanent sample plots now exist for this purpose. The earliest of these were established by district staff for demonstration purposes and were recently taken over by our program. The main bank of plots was established between 1967 and 1972 for a federal ARDA study and these have been augmented by our work in the Central and Southwestern Regions in the last 10 years. Many of the ARDA plots and the more recent Regional ones were located in groups within the same stand. In this way, site variation and differences in stand history between plots are reduced. We establish four 0.08 to 0.2 ha plots and determine the total basal area. Specific attention is given to stem quality. Other factors such as regeneration, mortality and general soil features are described. From this base a thinning regime is then established for each plot within the group. The thinning is then conducted by the district through cooperative research funding.

The improvement of tree quality is incorporated in the growth and yield observations after thinning. The emphasis is not only on more wood, but better wood as well. In addition, monitoring the response to different thinning levels will help reduce the disparity in agreement surrounding optimal thinning levels of hardwood stands in the province. These plots also serve as demonstration areas and as a source of other information, e.g. fuelwood in hardwood tops for district staff.

In a study conducted near Chatsworth, designed to provide information on long-term effects of thinning in a low-quality sugar maple (basswood-ash) stand. Current results indicate that the 20-year increase of the residual trees in the unthinned controls and the moderately and heavily thinned plots exceeded their initial volume by 92, 112 and 154% respectively. During the 20 years, total production of wood for the three above-mentioned density regimes amounted to 152, 227 and 265 m^3/ha while mortality losses ranged from 626 to 308 and 174 trees/ha in the same order of treatment. Additional information on defect, poor-risk trees and regeneration potential should further contribute to the selection of suitable options for the management of similar stands.

(Beckwith and Jaciw)

Maple Sap Production

Because of the large differences in sugar concentration between average trees and superior trees, it is important to select and mark superior trees as the first step towards improving a woodlot. Any subsequent remedial work in the woodlot such as thinning and fertilization can then be directed towards enhancing the growing conditions of these superior trees at the expense of the inferior ones.

Spot test readings of sugar con-

centrations in sap by means of refractometers were made randomly during the collecting season and the results compared with the average of the daily sugar concentration for the whole season from the same trees.

The spot test results can be misleading when the temperature is very low and there is a large difference in temperature between the sap and the measuring instrument (a refractometer at 20°C). Since there was a highly significant correlation between the width and depth of tree crowns and the sugar concentration, spot tests should be made in a population of such trees, so that those affected by hidden disease or insect factors may be eliminated. The dbh but not the growth rate of overstorey trees is important. Trees with a large dbh usually have the highest sugar concentration in their sap. The selection of trees on a fresh site should be made by spot testing during the peak sap flow of the current season.

In this study, soil P and foliar NP correlated significantly with sugar concentration, and foliar NP correlated significantly with total sugar yield. The soil pH 5.5 had a great bearing on fertilizer use. Sugar maple grows well from pH 5.5 to 7.3. However, at pH 5.5, P tends to become limiting and K tends to interfere with the uptake of Ca. K fertilization did not improve sugar concentration because at the rates applied, K interfered with the uptake of Ca. Ca became a limiting nutrient. Ca fertilizer at the rates applied was significantly negatively correlated with sugar interfered with the uptake of K.

Careful selection and care of sweet trees can result in continually improving sugar yields. By using the techniques of foliar and soil sampling on selected trees, limiting nutrients may be determined. Then by adding small increments rather than heavy applications of the required fertilizers, the demand for limiting nutrients may be gradually met.

Although the sampling of foliage for foliar analysis from the upper crowns of trees is the most reliable, sampling from the lowest green branch of the old growth overstorey sugar maple and from the upper crowns of the understorey regeneration is acceptable. Significant correlations can be shown between foliar nutrients from the two sources and soil nutrient levels (Table 3).

(Leech)

Within-Tree Growth Distribution

When the annual increment in cross-sectional area at the base of all roots in plantation-grown red pine was expressed as a percentage of that at the stem base, periods of relative increase and decrease in root area occurred in the 40 years analysed. These increases and decreases coincided with periods of increasing and decreasing moisture availability respectively. In trees whose crown size had been reduced substantially in years 5-27 by pruning live branches, diameter growth was reduced in the stem, but more so in the roots. Furthermore, the cyclical pattern in the comparison of root-stem cross sectional area increments did not occur.

These results suggest that where 'natural' crown development occurred, the changing availability of moisture caused continuing readjustments in the distribution of growth between the shoot and root as their relative supply-demand capacities changed. At the stem-root base, root thickening in relation to stem thickening was reduced when the moisture supply was reduced, and increased when the moisture supply increased. However when crown size was reduced by pruning, the supply-demand capacities of the shoot and root systems were perhaps brought into balance. The small crown size (transpiration area) may not have led to internal moisture stresses affecting root thickening directly or indirectly, but the reduced photosynthetic area may also not have allowed an increased supply of photosynthate for increased root thickening when moisture conditions improved.

(Fayle)

TABLE 3 Significant correlations (above .77 at 95% level) between percentages of nutrient concentrations (ODW) in foliage of sugar maple and soil nutrient levels (kg/ha)

Foliar nutrient	Soil nutrient				Foliar nutrient	
	N	P	K	Ca	N	P
Lower Crown of Overstorey						
N	.90					
P		.97				
K			.95		.78	
Ca	.77	.85				.74
Mg						.81
Upper Crown of Understorey						
N			.88			
P		.79				
K					.75	
Ca		.94		.95		
Mg		.85		.85		.73

Growth Models

Boreal Mixedwood Stands

As the boreal mixedwood forest is used more intensively as a source of fibre, the need for information on structural dynamics and yield becomes apparent. Growth models would enable foresters to predict which stands will need tending and when the treatment would be most beneficial. Such models could be used to forecast volume yield for stands of variable density and species composition, over a range of site types. This study will develop forest growth models to explain structural development and predict yield in both managed and unmanaged mixedwood stands.

Mixedwood stands on carefully selected sites were sampled to enlarge the data base initiated in 1980. Polar plots 0.125 ha in size were established, and approximately 700 trees were mapped in 3-dimensional space. This permits a detailed analysis of structure and increment inrelation to horizontal and vertical competition and several site factors. A computer model for this purpose is being developed on the basis of the total 2300-tree data base. Careful methodology is being stressed at this early stage, and stand reconstruction techniques for back-projection are being developed. Managed stand growth models will be produced following the application of specific silvicultural treatments to some of the plots. The semi-permanent plots will be reassessed for a 10-year period, and additional site types will be sampled to test and refine the growth models.

Preliminary analysis indicates that an optimum stand structure for gross volume increment is an inefficient arrangement of mixedwood species from the standpoint of current harvesting practices. The growth model should provide guidance for management on how to alter both the stand structure and the harvesting techniques for maximum efficiency of production and utilization.

(MacDonald)

Response Model to Partial Cutting Hardwood or Mixedwood Stands

A model has been developed, in cooperation with M.M. McLean, for the growth of all species and for the growth and yield of sugar maple for a period of 1-20 years after partial

cutting in hardwood or mixedwood stands on average and better sites in and near the Algonquin Region. Model parameters are: geographic location and elevation of the stand, mean daily temperature and mean annual precipitation for the area it is in, together with either a precut cruise of species by diameter-and quality-classes plus a determination of stems to be cut, or a postcut cruise plus a determination of what has been cut.

Examination of additional parameters such as slope, aspect, slope position, moisture regime, and other soil qualities is expected to provide further improvement of the model. However, even though it has not been verified by comparing it with other data, it tests so well against the data from which it was derived that it will be released for use in its present form without waiting for further refinement. This should permit managers to plan for those stands in which they intend to practice uneven-aged management.

OWOSFOP

The Ontario Wood Supply and Forest Productivity Model is being further modified to reflect more accurately the practices of FMA holders in reporting the updating of inventories and the surveying of not satisfactorily regenerated areas.

Georeferencing Data-Base

Substantial effort has been put into participation in the development of the georeferencing data base that was transferred from a PDP11/34 at the University of Guelph to a PDP11/50 at Queen's Park to two Perkin-Elmer 2230's at Queen's Park. When complete, this data base will store computerized (digitized) images of Forest Stand Maps, together with Forest Resource Inventory and Operational Cruise data; it will serve as a foundation for the Forest Management Agreement Area Information System.

One of the more important contributions was the development of a Double-Bounding procedure that will register a Township Map of any shape onto the FRI Basemap(s) contributing to it and transform the digitized points into a consistent Lambert Conformal base for Ontario, without using translocation-rotation procedures. It can also be used for transforming Ontario Basemaps into 6° UTM. It has the added advantage of removing the uncertainty of cursor placement along straight-line segments of map borders.

(Raymond)

Forest Ecosystem Classification and Mapping

The objectives of this program in the Clay Belt site district of Site Region 3E (within Cochrane, Kapuskasing, Hearst and Timmins districts) are 1/ to develop an ecological classification of the forest ecosystems of the Clay Belt, 2/ to provide an initial interpretation and evaluation of the ecosystem types for forest management, and 3/ to develop practical aids to identifying and mapping the ecosystem types, both on the ground and on large scale aerial photographs. The program, started in 1979 at the request of Northern Region, is conducted cooperatively with scientists from the Ontario Institute of Pedology (Guelph), Canadian Forestry Service (Sault Ste. Marie) and Canada Lands Directorate (Burlington) and Ministry staff from the Northern Region.

During the past 15 months, the very large data set on soil, site and vegetation features, gathered during the 1980 field program, was analysed and the refined 2nd Approximation Forest Ecosystem Classification was developed. This comprises 23 vegetation types and 14 soil types, grouped into 14 "Operational Groups". Field keys to the identification of these types and groups on the ground were designed and tested. Analysis was begun on the forest stand and regeneration data set. Mapping of the ecosystem distribution patterns within selected reference areas, using photo interpretation and ground survey, was started. Interpretation of the operational groups for forest management was pursued, in cooperation with district management staff. A start was made on the production of a two-volume guide to the forest ecosystems of the Clay Belt.

(Pierpoint)

Climatic Ecoregions of Canada

When knowledge or information on ecological relationships collected in one area is used for application in another one, some system is needed to allow comparison of the ecological conditions and to make adjustments before the information is applied. At the broadest level, the site regions of Ontario have been available for some time and have been used in silviculture and land management. In other parts of Canada similar regions have been or are being recognized.

In order to meet the need for an integrated Canada-wide system of ecological regions useful for forest management, an Ecoregion Working Group was established in 1978 under the auspices of the Canadian Committee on Ecological (Bio-Physical) Land Classification. Federal and provincial researchers are now working together to produce by early 1983 a climatic ecoregion map of Canada (scale 1:7 000 000) for inclusion in the Atlas of Canada.

The climatic ecoregions of Canada would - as the site regions of Ontario - illustrate the effect of macroclimate on species distribution and growth in relation to comparable niches in the landscape. That new map would deal with the forests and also with the prairie and arctic vegetation. In addition to the map, a separate report will be written in which several characteristics of each region will be described in some detail.

(Burger)

PAPERS AND POSTERS PRESENTED

Anderson, H.W. Biomass productivity and quality studies in poplar. International Energy Agency Meeting, Planning Group B, Toronto, Ontario, 27 March 1981.

Anderson, H.W. and L. Zsuffa. Genetically improved forest biomass energy production. Fourth Bioenergy R & D Seminar, National Research Council, Winnipeg, Manitoba, 29-31 March 1982.

Anderson, H.W. and L. Zsuffa. Genetically improved forest biomass energy production. 6th International Industrial Wood Energy Forum, Washingon, DC. 8-10 March 1982.

Colombo, S.J., (D.P. Webb) and C. Glerum. Cold hardiness and bud development under short days in black and white spruce seedlings. Canadian Containerized Tree Seedling Symposium, Toronto, Ontario, 14-16 September 1981.

Colombo, S.J. The shoot growth habit peculiar to second-year pine seedlings. Canadian Containerized Tree Seedling Symposium, Toronto, Ontario, 14-16 September 1981. (Poster)

Fayle, D.C.F. Roots: the underground edition, and What soil grade changes do to roots. 52nd Annual Ohio State University Short Course for Arborists, Columbus, Ohio. 25-26 January 1981.

Fayle, D.C.F. Roots. 9th Annual Green Industry Seminar and Trade Show, Detroit, Michigan. 4 November 1981.

Fayle, D.C.F. What soil grade changes and compaction do to roots. 33rd Annual Meeting, International Society of Arboriculture-Canada, Inc., Toronto, Ontario. 19 March 1982.

Glerum, C. and J.M. Paterson. Performance of container-grown and bare-root jack pine three years after outplanting on a northern Ontario cutover. Canadian Containerized Tree Seedling Symposium, Toronto, Ontario. 14-16 September 1981. (Poster)

Gordon, A.G. Genetics and genecology of spruce, Sault Ste. Marie, Ontario, 1979 and 1980. 18th Meeting Canadian Tree Improvement Association, Duncan, BC. 17-20 August 1981.

Gordon, A.G. The consequences of full-tree logging and biomass harvesting relative to maintaining forest ecosystem stability. Panel on Soil, site and watershed protection, Annual Meeting Ontario Professional Foresters Association, Sault Ste. Marie, Ontario. 29 January 1982.

Lozano, F.C. Assessing soil nutrient availability for hybrid poplars. International Energy Agency Meeting, Planning Group B, Toronto, Ontario. 27 March 1981.

McClain, K.M. Growth, nutrition and root development of Ontario tubelings, plugs and 3+0 bare root black spruce. Canadian Containerized Tree Seedling Symposium, Toronto, Ontario. 14-16 September 1981.

(Rauter, R.M.) and J.V. Hood. Uses for rooted cuttings in tree improvement programs. 18th Meeting Canadian Tree Improvement Association, Duncan, BC. 17-20 August 1981.

Zsuffa, L. Breeding of fast growing hardwoods and white pines at Ontario Forest Research Centre, Maple, and forest genetics and tree breeding at the Faculty of Forestry, University of Toronto. 18th Meeting Canadian Tree Improvement Association, Duncan, BC. 17-20 August 1981.

Zsuffa, L. The production of wood for energy. XVII IUFRO World Congress, Kyoto, Japan. 5-10 September 1981.

Zsuffa, L. Experiences in breeding Pinus strobus L. for resistance to blister rust. XVII IUFRO World Congress, Kyoto, Japan. 5-10 September 1981.

INFORMATION SESSION FOR FOREST MANAGERS

The yearly Information Session for Forest Managers, held under the auspices of the Canada Ontario Joint Forest Research Committee was organized this year by the Institute. Some people attended the session, held at the Kortright Conservation Centre, Kleinburg, 23-25 February 1982. In addition to poster presentation, the following papers were given:

Anderson, H.W. Studies of growth, quality and regeneration in tolerant hardwoods.

Anderson, H.W. Studies of biomass productivity and quality in hybrid poplar and willow.

Beckwith, A.F., S. Pessione and T.J. Taylor. Variable Density growth and yield of managed jack pine plantations.

Buchert, G.P. Hard pine genetics and breeding.

Burger, D. Site regions of Canada.

Campbell, R. Herbicides.

Fayle, D.C.F. The flowers in the garden grow downward.

Glerum, C. and S.J. Colombo. Improving the quality of overwintered containerized spruce seedlings.

Gordon, A.G. Importance of ecology in spruce breeding.

Ho, R.H. Cone induction and seed production.

Hood, J.V. Developing breeding strategies for spruce.

MacDonald, G.B. Boreal mixedwood dynamics and yield problems.

McClain, K.M. Studies of artificial regeneration in the boreal mixedwood forest.

Pierpoint, G. Forest ecosystem classification in the Clay Belt, Northern Region.

Skeates, D.A. Utilization of seed in artificial regeneration systems.

Weingartner, D. Possibilities for aspen silviculture in the Boreal mixedwood forest.

Zsuffa, L. Breeding of hybrid poplar, hardwoods and white pine.

SEMINARS CONDUCTED

Title: Tolerant Hardwood Silviculture
Duration: One-half day
Subject: Quality development in hardwoods
Participants: Forest technicians, Angus Work Centre, Central Region
Instructor: H.W. Anderson

Title: Hardwood Timber Marking Course
Duration: 1 day
Subject: Hardwood quality and growth assessment
Participants: Technicians from Bracebridge District, Algonquin Region
Instructor: H.W. Anderson

Title: Forest Ecology and Black Spruce Silviculture
Duration: 1 day
Subject: Field seminar on black spruce silviculture
Participants: Forestry field staff of Great Lakes Forest Products Ltd.
Instructor: K. McClain

Title: Soils Course, Northern Region
Duration: 5 days
Subject: Field recognition and interpretation of key soil features
Participants: Foresters and resource technicians (25) from Northern Region districts and industry
Instructors: G. Pierpoint, (R.K. Jones, E.P. Taylor, G. Wickware)

Title: Soils Course, Central Region
Duration: 5 days
Subject: Field recognition and interpretation of key soil features
Participants: Foresters and resource technicians (25) from Central Region districts
Instructors: G. Pierpoint, (R.K. Jones, E.P. Taylor, G. Wall, A. Montgomery)

Title: Instructor Training Course
Duraton: 5 days
Subject: Methods and techniques of instructing
Participants: 42 Ministry staff members
Instructors: (C. Peterson, D. Merrill, R. Briggs, D. Glays, N. Hook, S. Janes), G. Pierpoint, (R. Stevenson, E. Wolters)

Title: Tree Improvement Short Course for Timber Supervisors
Duration: 3 days
Subject: Presentation of genetic principles, operational procedures, research progress in tree improvement and forest genetics
Participants: OMNR Timber supervisors
Instructors: (R.M. Rauter), L. Zsuffa, G. Buchert, J. Hood, (L. Miller, K. Yeatman, W. Fogal)

Title: Tree Improvement Short Course for Northern Unit Foresters and Technicians
Duration: 3 days
Subject: Presentation of genetic principles, operational procedures, research progress in tree improvement and forest genetics
Participants: OMNR Northern Unit foresters and technicians
Instructors: (R.M. Rauter), G. Buchert, J. Hood, (L. Miller, K. Yeatman, W. Fogal)

Title: Tree Improvement Short Course for Southern Unit Foresters and Technicians
Duration: 3 days
Subject: Presentation of genetic principles, operational procedures, research progress in tree improvement and forest genetics
Participants: OMNR Southern Unit foresters and technicians
Instructors: (R.M Rauter), L. Zsuffa, G. Buchert, J. Hood, (L. Miller, W. Fogal, G. Murray)

UNIVERSITY INVOLVEMENTS

Drs D. Burger, D. Fayle and L. Zsuffa are adjunct professors at the Faculty of Forestry, University of Toronto. The latter two staff were appointed to the Graduate Department in 1981, and in 1982 Dr Fayle was also appointed to the Associated Graduate Faculty at the University of Guelph. Drs Zsuffa and Fayle supervise graduate students and serve on graduate committees; Mr Hood and Messrs Anderson and Beckwith also are members of graduate student committees. Dr Glerum served as an external examiner to a Master's thesis at Lakehead University.

One or more lectures to courses at the Faculty of Forestry, University of Toronto, were given by: H. Anderson (hybrid poplar wood quality, physiology, hardwood stand dynamics), D. Burger (planning and organizing applied research), D. Fayle (root systems, writing research reports), R. Ho (hybridization, cytogenetics), J. Hood (quantitative inheritance and heritability, selection), F. Lozano (exchangeable bases), P. Pelkonen (ecophysiology), D. Skeates (seed, provenances, germinant transplant systems), and L. Zsuffa (2 courses on forest genetics and tree breeding). At the School of Forestry, Lakehead University, lectures were given by K. McClain (regeneration, research management relations).

COMMITTEES

Besides serving on or participating in various Ministry committees, staff are involved as members or chairmen of different interministry, provincial, national and international committees or groups. These include Acid Precipitation in Ontario Studies, Canadian Tree Improvement Association, Ontario Institute of Pedology Technical Committee, Committee for Ontario Strategy for Land Resources Research, Export Committee on Soil Survey, Poplar Council of Canada, Forest Energy-International Energy Agency, and various IUFRO working groups.

VISITORS TO INSTITUTE

Visitors to the Institute from outside the North American Continent included those from the United Kingdom, Belgium, Holland, West Germany, France, Finland, Sweden,

Kenya, Japan, Philippines, Australia and New Zealand.

Groups visiting the Institute included members of Planning Group B (Biomass Growth and Production) of FE/IEA, students from Sir Sanford Fleming College, the Canadian Forestry Advisory Council, and management foresters attending the Information Session.

The Administrative Support Unit provides assistance in the areas of personnel, purchasing, word processing, computer systems, photography and statistics. The purpose is to ensure delivery of the research programs of the sixty professional and technical staff; and an additional forty temporary positions, augmented by up to one hundred casual employees during peak periods.

The following, published during 1981-82, may be obtained by circling the appropriate number(s) on the attached card and mailing it to the Institute.

1. Fayle, D.C.F. 1981. Internodal changes in ring width along a red pine stem. Mitteilungen der forstlichen Bundesversuchsanstalt Wien 142 (1): 57-66.

   Overall longitudinal changes in the width of the growth layer are a combination of changes within the internodes and at the nodes (branch whorls).

2. Fayle, D.C.F. 1981. What soil grade changes do to tree roots. Buckeye Arborist, May/June: 4-6.

   Factors that affect root growth, and the interrelations between the root and shoot systems are discussed to provide an understanding of potential effects of changes in soil grade.

3. Fayle, D.C.F. 1981. Frost rings formed in 14-m tall red pine. The Forestry Chronicle 57: 123.

   Frost rings had formed at the start of most annual rings in the two internodes below the current leader until the trees were nearly 14-m tall.

4. Fayle, D.C.F. 1981. Groove formation in the stem of red pine associated with branches. Canadian Journal of Forest Research 11: 643-650.

   The occurrence of grooves both above and below the base of branches indicates effects via both xlyem- and phloem-transported substances, with the former having a greater effect.

5. Glerum, C. 1982. A bud development study on one year-old container-grown conifer seedlings, p. 1416. In Proceedings Electron Microscopy Symposium, 3 February 1982, Toronto, Ontario. Ontario Ministry of the Environment.

   Bud development in containerized black spruce seedlings was improved by changing the cultural practices. This resulted in reduced overwinter losses, which were as high as 50% to less than 1%, and enhances subsequent field performance.

6. Gordon, A.G. 1981. Impacts of harvesting on nutrient cycling in the boreal mixedwood forest, p. 121140. In R.D. Whitney and K.M. McClain (eds.). Boreal Mixedwood Symposium. Canadian Forestry Service, COJFRC Symposium Proceedings O-P-9.

   Provides a biomass, productivity and nutrient cycling model for typical boreal mixedwoods and information in the impact and resilience of this forest ecosystem when subjected to full-tree harvesting.

7. (Haavisto, V.F.) and A.G. Gordon. 1982. Flushing black and white spruce flowers as an aid in predicting cone crops. Canadian Forestry Service, Environment Canada/Ontario Ministry of Natural Resources Leaflet. (Unnumbered.)

   Identifies and describes periodicity, growth habit and sex of black and white spruce flowers, and provides a simple method of forced flushing for evaluation of potential cone crops, budworm damage, etc.

8. Leech, R.H. and Y.T. Kim. 1981. Foliar analysis and DRIS as a guide to fertilizer amendments in poplar plantations. The Forestry Chronicle 57: 17-21.

   The use of foliar analysis in conjunction with the Diagnostic and Recommendation Integrated System (DRIS) of Beaufils is demonstrated in poplar clone D38 to guide fertilizer amendments and monitor subsequent tree growth by use of greenhouse and field standards.

9. Lozano, F.C. and (I.K. Morrison). 1981. Disruption of hardwood nutrition by sulfur dioxide, nickel, and copper air pollution near Sudbury, Canada. Journal of Environmental Quality 10: 198-204.

Soils on sites damaged by fumes and dustfall were impoverished in organic matter K, Ca and trace elements; S, Fe, Cu and Ni were increased, the latter two elements to toxic or near toxic levels.

10. McClain, K.M. 1981. Definition and distribution of the Boreal Mixedwood Forest in Ontario, p. 5-9. In R.D. Whitney and K.M. McClain (eds.). Boreal Mixedwood Symposium, Canadian Forestry Service, COJFRC Symposium Proceedings O-P-9.

A definition of the Boreal Mixedwood forest is presented in terms of species composition and site. Over 50% of Ontario's productive forest land lies within the boreal mixedwood forest, denoting its significance to the forest economy of the province.

11. Mullin, R.E. 1981. Water dipping and moss packaging for frozen overwinter storage of jack pine. US Forest Service, Tree Planters' Notes 32 (1): 3-5.

Water dipping and/or use of sphagnum moss was found unnecessary for frozen overwinter storage of jack pine in Kraft-polyethylene bags.

12. Mullin, R.E. 1981. Response of a white spruce and white pine planting to sulphur and fertilizer tablets. US Forest Service, Tree Planters' Notes 32 (2): 14-15.

Ten years after planting, white spruce and white pine showed little or no benefit from acidification with sulphur or from planting 'pills'.

13. Mullin, R.E. 1981. Effects of size of frozen stored 3+0 pine on field performance. Ontario Ministry of Natural Resources, Nursery Note No. 71. 6 p.

A test of three sizes of 3+0 red pine in overwiner storage showed no difference in storage capability.

14. Mullin, R.E. 1981. Seedbed density effects on red pine in the nursery and after outplanting. Ontario Ministry of Natural Resources, Nursery Note No. 72. 5 p.

Growth responses in the nursery and after outplanting indicate a direct relationship to seedbed density; lower density resulted in a better plantation.

15. Mullin, R.E. 1981. A container and water dipping test for overwinter storage of black spruce. Ontario Ministry of Natural Resources, Nursery Note No. 75. 6 p.

The polybin was successfully used for overwinter storage, and the stock should not be dipped in water previous to storage; moss was also not required in storage.

16. Mullin, R.E. and (C. Christl). 1981. Morphological grading of white spruce nursery stock. The Forestry Chronicle 57: 126-130.

3+0 seedling stock was found inferior to 2+2 stock in survival and growth: tentative recommendations are given for size of 2+2 stock as minimum 22 cm top length, minimum 4.0 mm stem diameter, minimum 5 ml root volume, and top-root ratio range (by volume) of 1.0 to 3.5:1.

17. Mullin, R.E. and R.E. Hutchison. 1981. The Dunemann option for Ontario. Ontario Ministry of Natural Resources, Nursery Note No. 73. 6 p.

Very promising results have been obtained from Dunemann stock in comparison with regular nursery stock.

18. Mullin, R.E. and (R.E. Laupert). 1981. Cold and frozen overwinter storage of white pine at St. Williams Nursery. Ontario Ministry of Natural

Resources, Nursery Note No. 70. 7 p.
Results indicate that cool storage may be more suitable than frozen storage at St. Williams Nursery, but more tests are required for other species.

19. Pierpoint, G., J.M. Paterson, J.G. Boufford and C. Glerum. 1981. Irregular growth of outplanted red pine. VI. The influence of handling and planting on fifth-year performance. Ontario Ministry of Natural Resources, Forest Research Note No. 29. 4 p.
Handling and planting procedures during field planting operations influenced survival, current height growth and total height, even after five years. Early monitoring of seedling quality as well as survival is possible and useful in assessing planting success.

20. Pierpoint, G. 1981. Site types in the boreal mixedwood forest, p. 10-16. In R.D. Whitney and K.M. McClain (eds.). Boreal Mixedwood Symposium. Canadian Forestry Service/Ontario Ministry of Natural Resources. COJFRC Symposium Proceedings O-P-9.
Soil and vegetation characteristics of three major divisions of the boreal mixedwood forest are described.

[1]21. Pierpoint, G. 1981. (Contributor). Field manual for describing soils. Ontario Institute of Pedology, University of Guelph, Publication No. 81-4.
A field guide for identifying and describing soil features and keying to interpretative classes.

[1]22. Pierpoint, G. 1981. (Contributor). Guide for describing key soil properties in the field. Ontario Institute of Pedology, University of Guelph, Publication No. 81-5.
An expansion of the field manual above.

23. (Webb, D.P.), S.J. Colombo and C. Glerum. 1981. Cold hardiness in relation to bud morphogenesis in Picea glauca and P. mariana, p. 326. Abstract in XIII International Botanical Congress, Sydney, Australia, Aug. 21-28, 1981.
In black and white spruce, bud development and rate of shoot elongation were strongly correlated with cold hardiness, positively and negatively respectively.

[2]24. (Whitney, R.D.) and K.M. McClain (Eds.). 1981. Boreal Mixedwood Symposium. Canadian Forestry Service, COJFRC Symposium Proceedings O-P-9. 278 p.
The proceedings, comprised of 25 papers, reviews current management procedures and problems in Ontario's mixedwood forests, with the intent of stimulating interest in, and improvement of, the management of the Boreal Mixedwood Forest.

25. (Wynia, A.) and K.M. McClain. 1981. How seedbed density can affect nursery stock costs. The Forestry Chronicle 57: 276-278.
The benefits of vari- able seedbed density in the production of seedling stock are discussed in relation to cost. While certain improvements in seedling morphology may be derived from low seedbed densities, higher associated production costs must be ultimately justified by post planting performance.

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[1] These two publications can be obtained from the Department of Land Resource Science, University of Guelph, Guelph, Ontario N1G 2W1 Canada.
Cost: No. 21 = $15.00; No. 22 = $5.00.
(Both require additional charges for mailing.)

[2] Obtainable from the Great Lakes Forest Research Centre, Canadian Forestry Service, Box 490, Sault Ste. Marie, Ontario P6A 5M7 Canada.

26. Zsuffa, L. and H.W. Anderson. 1981. The potential of poplar plantations, p. 99-109. In M. Chavarria (ed.) Simposio Internacional sobre las Ciencias Forestales y su Contribucion al Desarrollo de la America Tropical, San Jose, Costa Rica.

Hybrid poplar management systems in Ontario, the biomass yields and qualities, and the utilization potential are discussed in the new research and development experience in Ontario.

27. Zsuffa, L. 1981. The production of wood for energy, p. 403-413. In XVII IUFRO World Congress Proceedings, Division 3. Japan, 1981.

A global review of the projects in energy plantations.

28. Zsuffa, L. 1981. Experiences in breeding Pinus strobus L. for resistance to blister rust, p. 181-183. In XVII IUFRO World Congress Proceedings, Division 2. Japan, 1981.

The essential results of more than 20 years of work at Maple are summarized.

Should you wish to receive copies of any 1981 publications of the Ontario Tree Improvement and Forest Biomass Institute, please send your request to:

General Manager
Ontario Tree Improvement and
Forest Biomass Institute
Ontario Ministry of Natural Resources
Maple, Ontario LOJ 1EO
CANADA

(See the listing of publications for addresses to obtain numbers 21, 22 and 24.)

Sources of Funds:

Ontario Ministry of Natural Resources Forest Resources Group	$2 357 200
Ontario Ministry of the Environment	50 000
Ontario Ministry of Energy	32 500
Department of Regional Economic Expansion (DREE) Forest Management Subsidiary Agreement	686 500
Ontario Board of Industrial Leadership and Development (BILD)	209 300
TOTAL FUNDS AVAILABLE	$3 335 500

Uses of Funds:

Activity Component	Funds used[2] in-house	External contracts	Total
Tree Improvement	$736 700	$144 800	$881 500
Nursery/Arboreta/Greenhouse	141 500	0	141 500
Forest Biomass	286 300	0	286 300
Site and Productivity	605 730	641 070	1 246 800
Biology and Silviculture	327 300	9 000	336 300
Administrative Support	428 100	15 000	443 100
TOTALS	$2 525 630	$ 809 870	$3 335 500

[1] For the fiscal year 1 April 1981 - 31 March 1982.
[2] Permanent and casual staff salaries, travel, supplies and equipment.

Mr Douglas P. Drysdale was appointed as General Manager, Ontario Tree Improvement and Forest Biomass Institute in an executive secondment announced by Mr W.T. Foster, Deputy Minister, at the time the formation of the Institute was announced.

James Hood and Stephen Gourlay joined the Institute in January of 1981. James, a Research Scientist concerned primarily with spruce and larch breeding in the Tree Improvement Unit, came to us from graduate work in quantitative genetics at the University of California in Berkeley. Steve, a graduate forester from the University of New Brunswick, came to us from Nova Scotia where he operated a forestry consulting firm. As Executive Officer, he coordinates the financial accounting and research programming of the Institute.

Gordon Bain, who was employed as a Hybrid Poplar Technician for Harvey Anderson, resigned in May 1981 to pursue a career as a professional pilot.

The biotechnology segment of the Institute received a boost in April of 1981 when we obtained the services of Dr Yesoda Raj on a 3-year contract. Dr Raj has been involved in biotechnology studies in India, West Germany, the United States and Canada.

June and July of 1981 saw the addition of three new faces in the persons of Dr Chien-pin Chen, Donald MacIver and Gerald Racey (2-, 3- and 2-year contracts respectively).

Dr Chen, who possesses a background in wood physics and wood chemistry, is involved in the Hybrid Poplar Energy Survey supervised by H.W. Anderson.

Don MacIver provides statistical support for the Institute's research programs. His background experience includes an Assistant Professorship at York University in Toronto for eight years, and research consultation for the Northern Forest Research Centre of the Canadian Forestry Service in Edmonton.

Gerry Racey's biometrics background is being employed in Dr Chris Glerum's statistical analyses of the large quantities of data generated from Dr R.E. Mullin's (retired) experimental outplantings at the Midhurst Research area.

September of 1981 saw the retirement of Cedric Larsson, Research Scientist, Lowland Silviculture after a 35-year career in the swamplands and nectar-producing areas of southern Ontario. Even though Cedric has retired, we are assisting him in the finalization of various manuscripts on his work which should be published in the coming year.

Also in September the Institute benefitted with the arrival of Dr Paavo Pelkonen as a visiting scientist for one year from the Finnish Forest Research Institute. He has been involved in frost hardiness studies.

To enable research to be more responsive to the demands of forest industry and government several organizational changes were made. In essence, the programs are centralized under two broad Sections, namely, the Tree Improvement and Forest Biomass Section and the Forest Ecology and Silviculture Section, each headed by a Principal Scientist. Each Section is divided into two units headed by a unit leader. To centralize and strengthen the Administration function, an Administrative Support Unit was identified under the direction of the Executive Officer. The Institute's General Manager reports directly to the Executive Coordinator of the Forest Resources Group.

It is planned to establish a Technology Transfer Unit in 1982-83 to assist in the dissemination of research knowledge to the forest managers and to provide feedback to the scientists on management's needs.

ONTARIO TREE IMPROVEMENT AND FOREST BIOMASS INSTITUTE

D.P. Drysdale - General Manager
- P. Mueller (Secretary)

Administrative Support Unit

S. Gourlay - Executive Officer
- M. Johnstone
- J. Kucopy
- E. Beckwith
- B. Morrell
- J. Tonge
- J. Robinson
- J. Boufford

Tree Improvement and Biomass Section

L. Zsuffa - Principal Scientist
- S. O'Neill (Secretary)

Forest Biomass Unit

- H. Anderson (Leader)
- C.P. Chen*
- W. Beekers
- D. Fayle
- D. Weingartner
- P. Jaciw
- C. Papadopol*

Tree Improvement Unit

- L. Zsuffa (Leader)
- D. Boufford
- G. Buchert
- J. Hood
- D. Skeates
- D. Irving
- A. Gordon
- N. Jondreau
- N. Lussier
- M. Famiglietti
- R. Ho*
- Y. Raj*
- W. vanBorrendam*
- A. Mosseler*

Nursery/Greenhouse/ Arboreta Unit

- K. Bennett (Leader)
- D. Gamble
- M. Weishar

Int'l Energy Agency
Forest Energy Biomass
Growth and Production

- D. Morgan

Forest Ecology and Silviculture Section

D. Burger - Principal Scientist
- O. Kent (Secretary)

Site and Productivity Unit

- G. Pierpoint (Leader)
- A. Beckwith
- T. Taylor
- R. Leech
- Y.T. Kim
- F. Raymond
- L. Spence
- C. Gocool
- A. Morris
- B. MacDonald

Silviculture and Tree Biology Unit

- C. Glerum (Leader)
- J. Paterson
- J. Stoddart
- R. Hutchison
- L. Bowdery
- G. Stroempl
- M. McLean
- W. Ohlmann
- I. Palmer
- S. Colombo*
- D. McMillan*
- G. Racey*
- P. Pelkonen*
- D. MacIver*

Northern Boreal Forest Research Unit

- N.F. Lyon (Leader)
- K. McClain
- N. Knudsen
- T. Casella
- R. Forslund
- G. Page
- D. McMillan*

* Contract Positions

1982 03 31